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"Food safety and traceability"

ORAL PRESENTATION

Farm internal traceability and ecolabelling to improve environment safety: the case of greenhouse vegetables

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Abstract

It is well known that, for some years now, Europe Union contemplate a system aimed at giving an environmental impact label to different no-food products, the so-called European Ecolabelling. It allows the consumers to easily identify "green" products and the producers to inform the consumers that their products are environment-friendly. More recently, at national states level, there is a growing interest toward a similar system also for the food chain. Internal traceability, that is the linking up of all inputs to outputs is, as far, a voluntary act. With the objective of getting the ecolabel of a farm produce (together with collecting data for a better management of the farm production processes) the implementation of an internal traceability system at farm level in the case of greenhouse vegetables cultivation has been considered.

The traceability system is very simple at the moment: every greenhouse has been equipped with a sheet-card where each work and material input is reported. These data are then periodically collected, transferred and elaborated by a common "electronic-sheet" application. The collected data allow evaluating an impact indicator to the products and to the different inputs of the process. The analyzed vegetables are radish and basil, this last one grown either in summer or in winter. As environmental impact parameters we have used both energy cost and greenhouse effect like CO_2 emissions equivalent.

The obtained results for radish and basil indicate that regardless the cultivation technique, package and heating and lighting represent great part of environmental impact, as energy cost and CO_2 emissions eq. Radish cultivated in greenhouse in summer, and packaged for supermarket has an energy cost of 10,6 MJ/kg, more than 55% due to package. For summer cultivation of basil, more than 90% of total energy cost, and CO_2 emissions is due to package, with total energy cost of 48 MJ/kg. For winter cultivation of basil, heating and lighting represent more than 86% of total energy cost, packaging included, (368 MJ/kg), and more than 96% of total CO_2 emissions eq. (22,7 kg/kg).

Keywords: impact, energy-cost, greenhouse effect.

Introduction

Traceability requirements stated by the General Food Law Regulation 178/2002 and come into force the 1 January 2005 do not, however, require 'internal traceability', that is the linking up of all inputs to outputs. The adoption of an internal traceability system is thus a voluntary act. Section 2 of the mentioned law specifies that vegetable produce before harvesting is not considered food. So, the farm is partially excluded from traceability obligations.

In the fresh fruit and vegetable sector, a distinction is done between loose and packed produce. Packed food is subjected to stronger constraints due to labelling requirements (INDICOD-ECR, 2004). The label is in fact, the tool with which end-consumers are informed about the packed food.

It is well known that, from some year, Europe Union contemplate a system aimed at giving an environmental impact label to different no-food products, the so-called European Ecolabelling (European Union Eco-label, 2007). It allows the consumers to easily identify "green" products and the producers to inform the consumers that their products are environment- friendly. More recently, at national states level there is a growing interest toward a similar system also for the food chain. Emphasis is given on associating to the different foodstuff en environmental impact indicator, like CO_2 emissions.

Starting from the assumption that the objective of getting the ecolabel of a farm produce (together with collecting data for a better management of the farm production processes) seems enough strong to justify the cost of introducing an internal traceability system at farm level, the Authors report the results of a first application of such a system in the case of greenhouse vegetables cultivation.

Materials and methods

The analyzed vegetables are radish and basil, this last one grown either in summer or in winter. The farm of experimentation is located nearby Firenze and vegetable cultivation is mainly in greenhouse for a total of 85 units and a surface extension of 54000 m^2. About 90% of the production consist of "rucola", basil and radish in equal percentage.

Table 1. Energy and CO_2 emission coefficients

		Energy	N2O	CH4	CO2	GWP CO2 eq
	unit quantity	MJ	mg	g	g	g
Diesel fuel	kg	51,5	8,0	4,35	3500	3519
Nitrogen	kg	75,4	10012	8,09	1269	3003
Phosphorus	kg	8,8	39,9	3,80	2995	3017
Potassium	kg	10,5	8,6	0,69	542,8	547,0
Fungicide	kg	217,0	140,0	27,50	9500	9634
Insecticides	kg	420,5	328,0	52,50	23020	23286
Plastics	kg	94,0	15,5	13,45	1677	1733
Seeds	kg	50,0	4,2	1,01	525,8	530,6
Tractors	kg*h	0,014	0,010	0,0016	0,83	0,8
Equipments	kg*h	0,034	0,024	0,0037	1,99	2,0
Human Labor	h	7,33	0	0	0	0

The traceability system is very simple at the moment: every greenhouse has been equipped with a sheet-card where each work and material input is reported. These data are then periodically collected and transferred in a computer were, by a common "electronic-sheet" application, are then elaborated. That solution has been preferred by the farmers in alternative to more complex informative systems based on the use of specific and dedicated hardware and software. As impact parameters we have used both energy cost and greenhouse effect. The approach followed is that of Life Cycle Assessment, that is to consider "*the entire* *life-cycle of product, process or activity, encompassing extracting and processing raw materials, manufacturing, transportation and distribution, use, re-use, maintenance, recycling, and final disposal...."* (SETAC, 1993). With the aim of harmonising the different approaches used in applying LCA (Life Cycle impact Assessment) to agriculture, in 1995 the European Commission promoted a concerted action (AIR3-CT94-2028) the final report of which (Audsley, 1997) has be taken as reference in the present application. Specific coefficients used to assess the "Energy resources depletion" (here said Energy costs) and "Global Warming Potential" (green house effects) of every input are reported in Table 1. In the table are also indicated the specific value of gas emissions responsible for green house effect, namely CO_2, N_20, CH_4. Their impact effect in term of Global Warming Potential (GWP) are here evaluated on a time scale of 500 years and expressed in g (grams) equivalents of CO_2. The values of CO_2 equivalents for N_2O and CH_4 are obtained by multiplying their values by a factor of 170 and 4, respectively.

Table 2. Energy cost and GWP effect due to the different inputs for a kg of product.

		RADISH SUMMER		BASIL SUMMER		BASIL WINTER	
		Energy cost MJ/kg	GWP CO2 eq g/kg	Energy cost MJ/kg	GWP CO2 eq g/kg	Energy cost MJ/kg	GWP CO2 eq g/kg
	Diesel fuel tractor	0,97	66,0	0,25	16,8	0,25	16,8
	Diesel fuel cogenerator					318,8	21783
	Direct inputs	0,97		0,25		319,0	
	Machinery	0,13	20,9	0,03	5,71	0,03	5,71
	Cogenerator					0,80	83,1
	Fertilizers	0,99	53,2	0,28	14,8	0,28	14,8
	Pesticides	0,01	3,49	0,02	4,55	0,02	4,55
	Seed	0,08	1,46	0,02	0,31	0,02	0,31
	Irrigation pipes	1,88	36,1	0,52	10,1	0,52	10,1
	Labor	0,69		1,79		1,79	
	Indirect inputs	3,78		2,66		3,46	
	Total	4,75	181,1	2,91	52,3	322,5	21918
	Package (300 g of radish)	5,86	108,0				
	Package (60 g of basil)			29,3	540,1	29,3	540,1
	Package (30 g of basil)			45,1	831,8	45,1	831,8
TOTAL	Packaged product	10,6	289,1	32,2 48,0	592,4 884,1	351,8 367,6	22458 22749

The descriptive and computational LCA model used in the present application is a simplified version of that reported in reference (Spugnoli et al. 2005) where the similarity in expressing the total impact of CO_2 end Energy efficiency is also underlined. The aptitude of the energy analysis parameters in representing the environment impact is exemplified in reference (Spugnoli et al. 1993). A fundamental step in LCA impact analysis of a process is the allocation of environmental effects to each production phase referring them to the functional unit. This is done by considering and registering the quantities of the input flows used in all the different phases of the process, which is typical of the internal traceability activity.

Results

The results of the process analysis, performed on the farm examined, are reported in table 2. The data refer to unit of product (kg). For radish in summer, as regard cultivation phase, the data show higher energy costs for tractors fuel (20,3%), as direct inputs, and for fertilizers (20,9%) and irrigation pipes (39,6%) as indirect inputs. GWP is due especially to fuel (36%) fertilizers (29%) and irrigation pipes (20%).

Package has a very high impact in terms of energy costs (55%) and GPW (37%).

For basil in summer labor has the highest impact in terms of energy cost relatively to the cultivation phase (62%), while for GWP, fuel represent 32% and fertilizers 28%. Package has for basil a very high impact, due to the very small quantity of product for each package (30-60 g), so for one kg of basil, package weight 91-94% both in terms of energy cost than in GWP.

The cultivation of basil in winter needs to maintain temperature not below 18-20 °C, and an artificial lightening equivalent to that of summer: to recreate that conditions the energy cost is terribly high and represent more than 99%, that is 319 MJ/kg of basil. The same stand for GWP, with almost 22 kg of CO_2 equivalent for kg of basil.

Table 3. Impact weight of the production phases.

	RADISH SUMMER				BASIL SUMMER				BASIL WINTER			
	Energy cost		GWP CO2 eq		Energy cost		GWP CO2 eq		Energy cost		GWP CO2 eq	
	MJ/kg	%	g/kg	%	MJ/kg	%	g/kg	%	MJ/kg	%	g/kg	%
Cultivation	4,75	44,8	181,1	62,6	2,91	6,06	52,3	5,91	2,91	0,79	52,3	0,2
Heating and Lightining	0	0	0	0	0	0	0	0	319,6	86,9	21866	96,1
Packaging	5,86	55,2	108,0	37,4	45,1	93,9	831,8	94,1	45,1	12,3	831,8	3,7
Total	10,6	100	289,1	100	48,0	100	884,1	100	367,6	100	22750	100

Conclusion

Traceability, apart its proper original purpose, could become a start point for a widespread of ecolabelling. Infact, internal traceability - as far as economic, energy or LCA analysis - requires the allocation of the process inputs in the different production phases, so that the quantity of every input needed for a unit of output could be established. Than, the computation of the energy requirement or CO_2 emissions is only a question of coefficients knowledge. For monetary costs of course, you have only to know the prices.

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I.S. Project: a methodology of evaluation for integrated systems in agroindustrial sector

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Abstract
A possible integration of Quality, Environment and Health & Safety Management represents an object of interest for scientific community, experts, category associations and companies.
The main problem of such integration is the characterization of critical points and non conformity in companies processes.
The aim of the research is to realize a tool for verifying the management of food safety and quality, the management of work place safety and environmental security in agro industry. In this way it will be possible to find out the points of weakness of the production system.
In order to analyze the processes of a company, a mechanism based on ten macro indicators has been planned. Every macro indicator is carried out answering to several questions through which the relevance of the problem for every company, the plant engineering and the organization is identified. Every answer has a score, 1 represents the most critical situation and 4 the best one. Using a simple algorithm, it is possible to evaluate every single macro indicator.
A "radar" diagram allows to identify the weakness and strength points of a company. The global safety level of a company is so represented by the surface of the diagram. Particularly the model has been applied to several kind of agroindustrial companies, above all dairies, stockbreeders and hazelnut growers. Several diagrams have been drawn using this methodology.

Keywords: integrated management system, food quality, environment, work safety.

Introduction
Agro-industry and agro-alimentary have always been sectors involving different activities and types of professions, as well as types of markets subject to numerous singled out critical points regarding safety and health (OHSAS 18001:1991) (injuries, professional illnesses), food quality and industrial activity's consequences to the environment (environmental impact) [5] . The goal of this research is to produce an instrument easily adaptable to every industry's characteristics, able to join the above stated three aspects defining a frame of the situation of the main existing issues in a simple and easily understandable way for all the individuals involved in the agro industrial trade.

Material and methods
To realize this elaboration check-lists to gather data have been created and used. These check-lists are instruments for self evaluation which assure that important aspects are not neglected. The check-lists permit to verify carefully the status of implementation of health and safety, environment and product's quality norms, drawing the companies' picture in these fields. The files used for survey in some companies have been conceived to support the analysis of systemic safety of the anthropic environment in agro-industrial fields [6].

The check-lists are based on the European legislation in force and therefore they need to consider any eventual successive updating. In the compilation of the check-list all the types of professions and possible users on site have to be involved. It needs to be done every time that the purpose and the logistics of the working activities are modified.

In this research three check-lists have been created and elaborated: the first regarding the employees' health and safety aspects; the second regarding the food products' safety and quality. The last one is regarding the evaluation of the environmental aspects.

Every check-list has been divided into 10 macro-indicators or areas of observation and specific questions have been asked for each of these. In each macro-indicator there are three types of questions (or sub-areas of observation), based on:

- Relevance (meaning the importance given to each single aspect) [7];
- Management-Organization aspects (meaning the management of the aspect, i.e. assignment of duties and responsibilities and training of personnel);
- Technological-Structural aspects (meaning the suitability of machinery and environment).

Each question asked in the various macro-indicators verifies in a direct way if a particular legislative norm has been applied and/or respected or if there is the presence of a non conformity.

Four answers have been associated to each question and every answer has a value from "1" to "4"; the answers with the lowest value (1), correspond to situations that are not conform to, or do not respect the norm. The answers with the highest value (4) correspond to an optimal situation, respecting the procedures and legislative norms. The two answers with the medium values either identify the vicinity to the optimal condition (value 3) or to the worst condition (value 2).

<u>*Analyzed Companies*</u>

The editing of this elaboration in its experimental phase has been made possible thanks to the cooperation and aid of some firms in the-agro industrial sector in the Viterbo territory, in the centre of Italy. The captured data have been elaborated and published in an anonymous way not to recognize each single company.

For ease of use to each single farm was given an arbitrary name: Company "I", Company "II", Company "III" and Company "IV". Company I is a nuts manufacturer, with a working capacity of about 1000-1200 t/year of conventional product and 200-250 t/year of organic product. Company II is another nuts manufacturer. Its working capacity is about 2800-3000 t/year. The Company III's activity is meat manufacturing and sale. The company has been recently constructed. Company IV is a dairy produce company.

Following are the reports for each company in a radar graphic (figures 1 ÷ 4), constructed on the values reported in the check-lists and formulated on the answers to the macro-indicators' questions.

Results

<u>*Company I*</u>

From the radar graphic regarding working safety for the Company I is understandable that 5 macro-indicators out of 10 have been classified as weak points (Valuation of health and Safety risks; I.P.D. – Individual Protection Devices; Health surveillance and Monitoring). None of the 10 has been classified as a strong point. The macro-indicator concerning the

I.P.D. has been classified as "Not acceptable" because during the valuation on the company site, not all the workers were equipped with I.P.D.

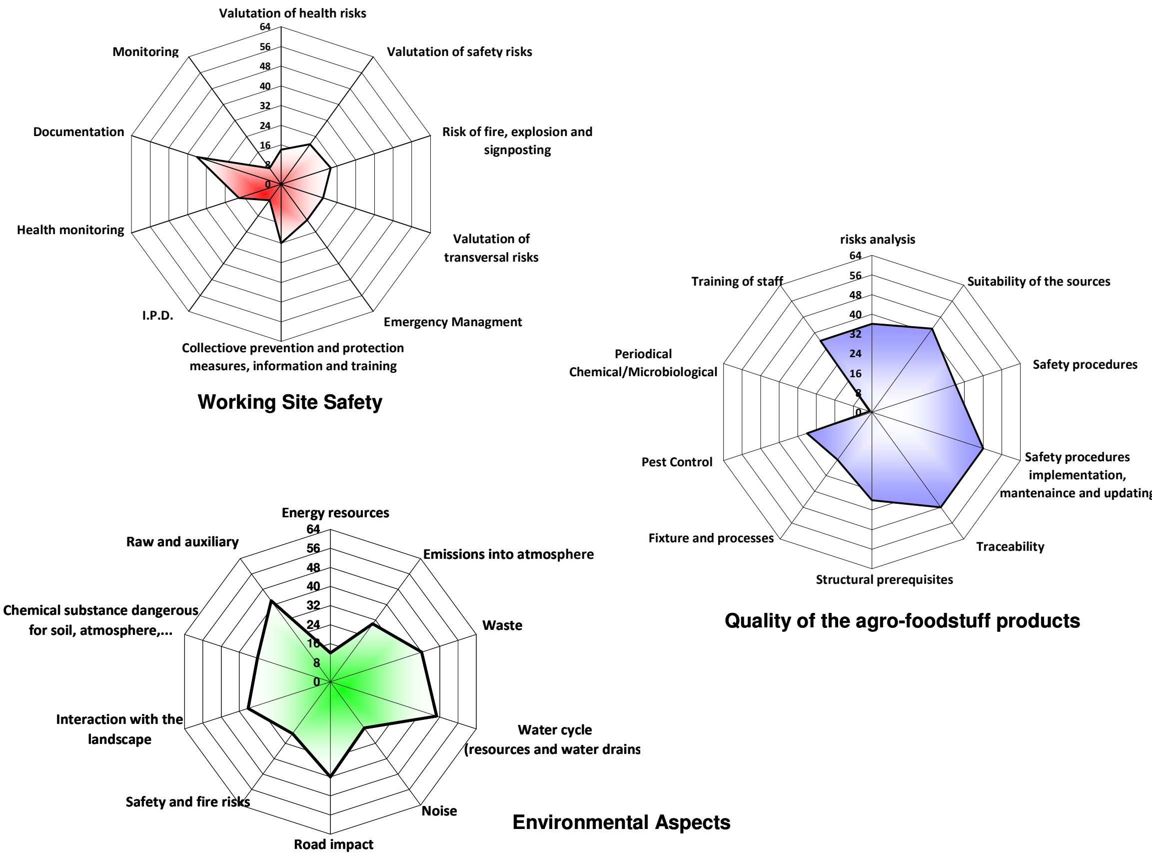

Figure 1. Integrated management system for Company I: radar graphics

On the contrary, Health Surveillance is executed only to fulfil law's obligation and often the competent doctor does not take part in the P.P.S. (Protective and Preventive Service) reunions. Finally, regarding the Monitoring of prevention and protection measures and of the documentation updating, this is sufficiently carried out but without following any criteria. From the check-list analysis regarding the quality of the agro-foodstuff products and from the relative radar graphic, it results a much better situation than the previous one. The analysis has singled out only 1 macro-indicator that can be classified as a weak point (the one concerning the periodical chemical/microbiological analysis) and 1 macro-indicator classified as a strong point (the application, maintenance and updating of safety procedures), with a value greater or equal to "48". Through the check-list regarding the environmental aspect valuation it is possible to single out 2 macro-indicators classified as weak (Energy resources and Noise) and none of the observation areas have been classified as strong points. Analyzing the weak points, the macro-indicator concerning energy resources results not to be acceptable because no energy saving system is in use even though the company is considering the possibility of alternative and/or renewable energy source applications. Regarding the noise, meant as acoustic pollution toward the outside, not all the emission sources have been singled out but it needs to be said that this problem exists only for a few months throughout the year (working period).

Company II

From the elaboration of the check-list and from the relative radar graphic regarding working safety for the Company II is understandable that there are no macro-indicators resulting acceptable, therefore all the observation areas are classified as weak points. The situation regarding the radar for the quality of the agro-foodstuff products is similar to the previous one. There are, in fact, 9 weak points on which the company urgently needs to work to arrive as soon as possible to an acceptable situation for the competent authority but also for suppliers and consumers. Finally, from the elaboration of the check-list regarding the valuation of environmental aspects only 2 macro-indicators have been singled out and classified as weak points (Energy resources and interaction with the landscape). Studying in depth each weak point, the macro-indicator regarding the energy resources results not acceptable because Company II does not use any energy saving system even though it keeps itself informed about the possibility of alternative and/or renewable energy sources. Regarding the interaction with the landscape, the structural characteristic of the company presents considerable contrast points with the surrounding rural territory. To make these weak points able to reach a situation of acceptability the company should operate adopting an energy saving politic (e.g. the use of modular variation) and using, at least partially, alternative and/or renewable energy sources.

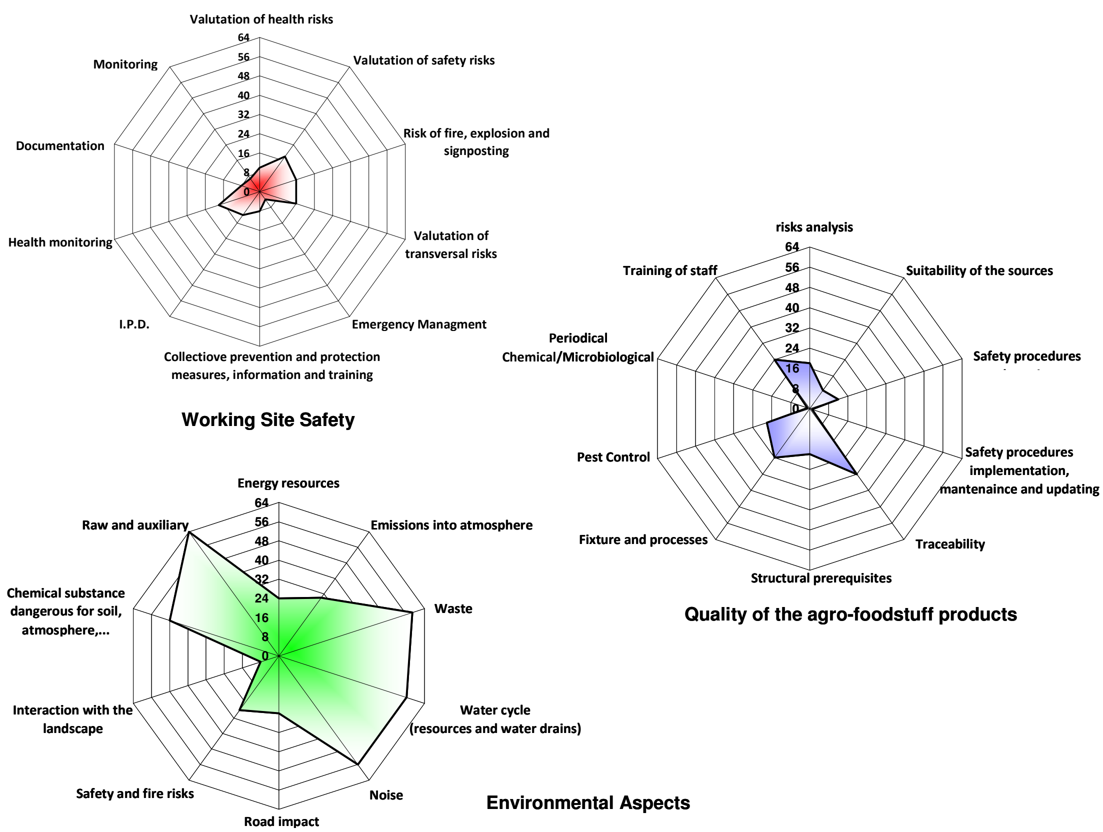

Figure 2. Integrated management system for Company II: radar graphics

Company III
From the elaboration of the check-list and from the relative graphic regarding working safety in the agro-alimentary industries, 4 macro-indicators have been singled out and classified as weak points (Valuation of transversal risks; Emergency management; I.P.D. and Monitoring), while only 1 has been classified as strong point, the documentation. From the analysis of the safety and quality of agro-foodstuff products and from the relative radar graphic only 1 macro-indicator has been classified as a weak point (the one regarding the structural prerequisites). Two macro-indicators have been classified as strong points (application, maintenance and updating of safety procedures and traceability), with a value greater or equal to "48". Throughout the check-list of the environmental aspects valuation 4 macro-indicators have been singled out and classified as weak points (Energy resources; Noise; Safety and fire risks; interaction with the landscape) and 2 observation areas have been classified as strong points (Waste; Raw and auxiliary materials).

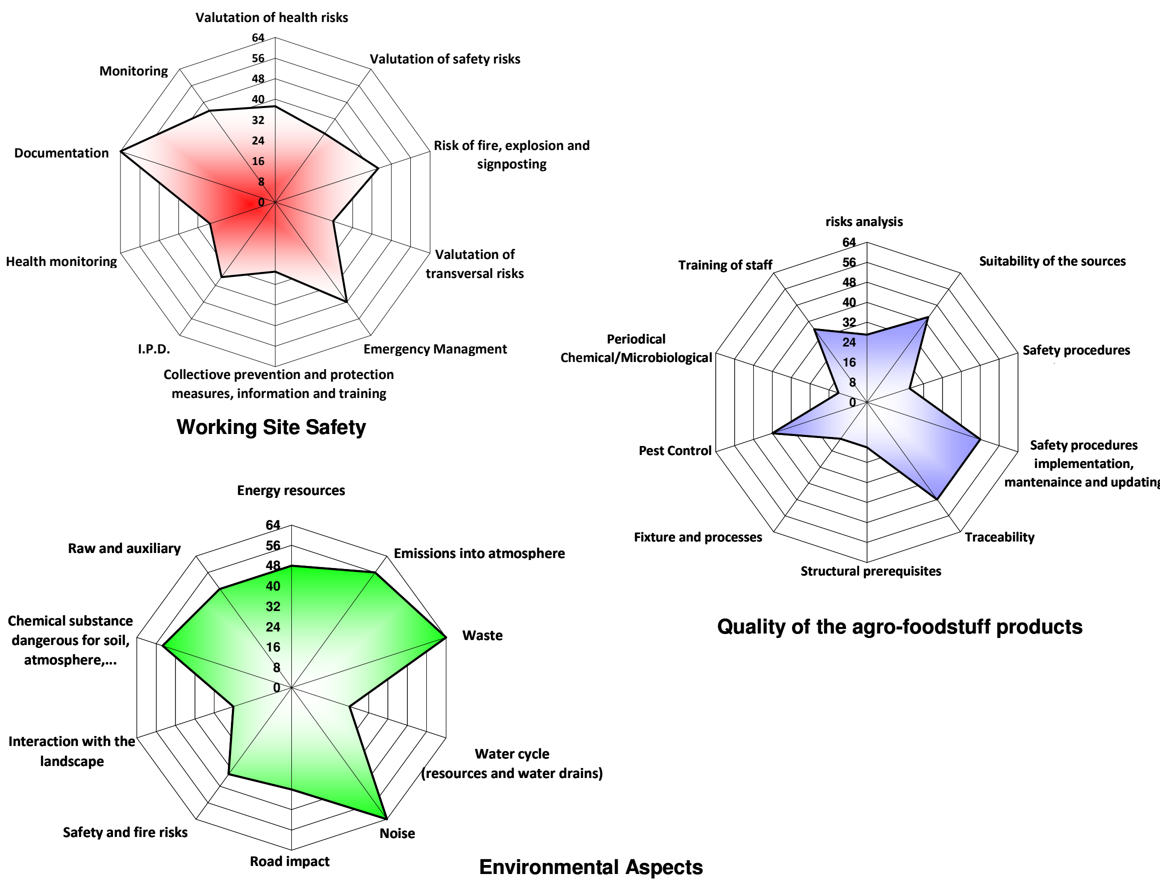

Figure 3. Integrated management system for Company III: radar graphics

Company IV
Regarding working safety and products' quality in the agro-alimentary industries for Company IV there are no macro-indicators classified as weak. Regarding the quality, only the

products traceability is not in an optimal situation; this is because of a lack of information campaigns, from the company, regarding the matter defined in the CE 178/2002 regulation.
Finally, from the analyzed check-list and from the relative graphic regarding the environmental aspects, 8 macro-indicators have been classified as strong points and only 2 have been classified as weak points. The macro-indicators that did not reach a situation of strength are the ones regarding the road impact and the interaction with the landscape.

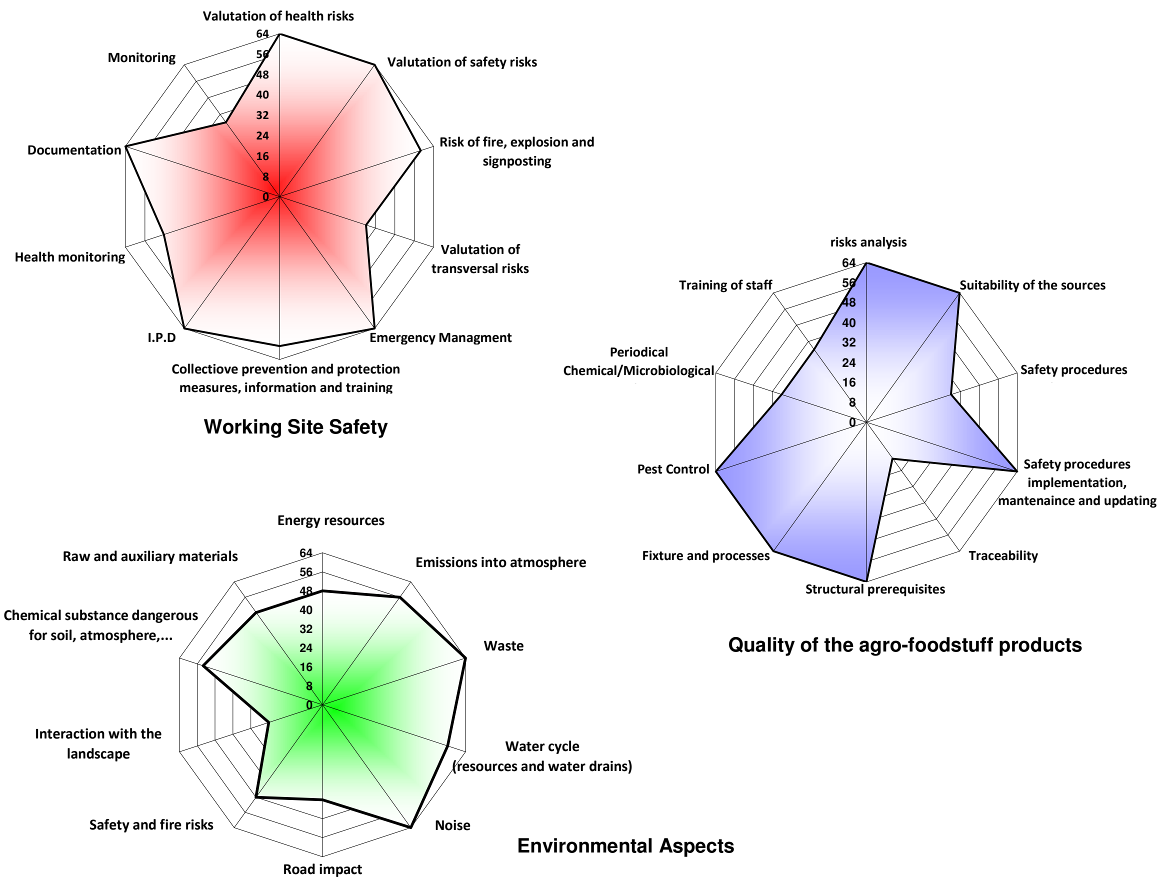

Figure 4. Integrated management system for Company IV: radar graphics

Conclusions

The methodology introduced in the present paper has been developed within the project PRIN 2005 "IS Project" (national coordinator Prof. Giorgio Zoppello, local coordinator Prof. Danilo Monarca).
The model described in this paper permits a synthetic description and a simple and clear visual approach of the farm technical aspects, referring to safety at work, product quality and the environmental effects related to the working activity.
The model has been developed in order to fit all the different kind of farms, trying to match the local farm typologies, typically of small or medium size, but also optimizing it for larger farms.
Furthermore, the radar diagram makes easier the individuation of the critical points.
Indeed, once the observation areas belonging to the three type of check-list have been classified, the surface values of all the radar diagrams described in the article can be calculated. These values can be utilized as instrument to classify, instead of the macro-

indicator conditions, the general farm conditions related to safety at work, agri-food product quality and environmental aspects.
In order to do so, a minimum value of acceptance has been fixed. This value equals to the value of the area of a hypothetical graph, where for each observation area has been assigned a numeric index corresponding to "27" (which is the acceptance value for each macro-indicator, obtained giving to the three observation sub-areas the average value of "3" that is, in a "1" to "4" scale, the value corresponding to the optimal situation). From the elaboration it results a limit value of minimum acceptance equal to "2142".
Comparing this value with the respective values obtained from the radar graphs related to safety at work, product quality and environmental aspects, it is possible to individuate for each type of macro-indicator (safety at work, product quality and environmental aspects) which farms have an acceptable general situation.
The check-lists have been tested on farms of the mentioned sectors.
In conclusion, farms that reach an acceptable situation have excellent bases for the implementation of an integrated management system for Quality, Environment, Health and Safety, due to the intrinsic ability of utilize all the synergies (documents, review process, audit, improvement), guarantying the maximum efficiency and reducing the costs.
The proposed approach can be easily extended to other management systems like Social Responsibility and Information.

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ICT and modelling methodologies for food safety and quality assurance in food production plants

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Abstract

In many food processing operations, product safety is still controlled by checking only the end product by microbiological and chemical methods. When unsafe food products are detected, part of the production has to be diverted and production process must be halted until the conditions causing unsafe product are diagnosed and eliminated. Fault diagnosis methods that can quickly identify the source causes that yield unsafe products would reduce the process down time and productivity loss. Monitoring and controlling processes are therefore crucial to ensure safety constraints, product quality, environment constraints and minimum cost simultaneously.
Aim of this paper is to present a novel approach for modelling and monitoring an industrial food process to be used for detecting abnormal behaviour of the process.

Keywords: food plant modeling, fault detection, food engineering, food safety.

Introduction

In many unit operations in food industry, product safety is controlled by checking only the end product by chemical and microbiological methods. When unsafe food products are detected, part of the production has to be diverted and production process must be halted until the conditions causing unsafe product are diagnosed and eliminated. The major drawbacks associated with this approach are the time delay and the amount of product that generally has to be discarded. Consequently, the development of fault diagnosis methods, that can quickly identify the source that caused unsafe products, would reduce the process down time and productivity loss. When inadequacies of traditional food safety control, based on end product analysis, have been noticed, more effective ways to control the safety of food processing lines have been sought. The systematic and scientific approach called *Hazard Analysis and Critical Control Points* (HACCP) was first used in 1960s and it has been developed in the further 30 years (see e.g. Khandke & Mayes, 1998; Tokatli et al, 2005). Instead of checking only the properties of the end product, Critical Control Points (CCP) of the process are individuated and continuously monitored to prevent a possible major hazard in advance. Critical limits on specific measured variables (CCP) are used to ensure the safety of the product. Any measurement outside the critical limit indicates insufficient/inadequate treatment. This approach, in industry, is generally referred as *Statistical Quality Control* (SQC). A property is plotted on a control chart where appropriate limits are known (for example for microbial charge) or have been defined on the base of statistical analysis of previous good operation. The use of real time in-line data acquisition systems and/or analyzers allows to collect more frequent quality data, but still perform SQC. Unfortunately SQC does not guarantee that the process is in control, even if single measurements are within acceptable limits.

Early detection of upsets in the process variables can be performed by the so called *Statistical Process Control* (SPC) technique (Hayes *et al.*, 1997; Ittzés, 2000; Srikaeo *et al.*, 2005).

The reduction of the number of the investigated variables, that in some cases can be large, can be performed using multivariate projection methods (Kourti & MacGregor, 1995). According to these methods, among which Principal Component Analysis is one of most diffused, a small number of new variables are calculated.

Monitoring and controlling process are therefore crucial to ensure safety constraints, product quality, environment constraints and minimum cost simultaneously. Some methodologies have been introduced in this context for the analysis and control of manufacturing processes. *Process analytical technology* is technique recently proposed by Kourti (Kourti, 2006) and it is based on timely measurements during processes of critical quality parameters and performance attributes of raw and in-process materials and processes to assure acceptable end product quality at the completion of the process.

In this paper, a model based approach to monitor an industrial food process and detect abnormal behaviour of the process variable is presented. Such anomalies can be caused by sensors/actuators failures (physical failure) or by an improper (e.g. excessive working load, properties of raw materials etc.) usage of the plant. The effectiveness of this method relies in the accuracy of the model that is used to simulate the process in healthy conditions. Section 2 of this paper undertake the problem of the development of the models in the case of plants operating on fluid products taking into account possible mass-flow discontinuities and thermal exchanges. The estimation of relevant entities, as e.g. flow rate, permanence time and temperature profiles, is carried out using numerical procedures that require the joint quantization of time and mass flow variables. The simulation is driven by the state of the plant (i.e. opening state of the valves, state of the motors, temperature of the service fluids etc). The nature of the model is necessarily hybrid since it accounts both continuous variables (e.g. temperature) and discrete events (e.g. motors on-off, valves openings etc.). This approach has some analogies with this adopted in Dabbene *et al*., 2008 for the modelling and optimization of fresh-food supply chains.

Finally, Section 3 presents a fault detection structure which operates analysing discrepancies between measured and estimated variables and Section 4 reports some conclusions.

Model development

The first step in the development of a tool for the diagnosis of faults and/or quality loss in food production plants is to build a model to simulate the plant in healthy conditions. When considering plant operating on fluid products, the main difficulty in modelling is to manage the flow discontinuities that some devices, such as valves, can introduce.

The model of a plant can be constructed as the interconnection of distinct modules, hereafter referred as node, whose description is derived from mass and energy balances. The product flows through nodes which are typically responsible of specific unit operations such as heating, cooling, storage, filling etc.

Define as *continuous-flow node* a node that does not internally store any amount of product. For this kind of node, incoming and outgoing flow rates are always equal.

On the contrary, a *discontinuous-flow node* is able to temporarily store amounts of product, so that incoming and outgoing flow rates can differ. Examples of a discontinuous-flow node are batch evaporators, holding or buffer tanks etc. The permanence time of the product in these nodes is not constant and cannot be, in many case, deterministically determined.

Since model parameters need to be identified on the base of measurements on the plant, model components are hereafter introduced in the discrete time domain, assuming a sampling period Δt. Analogously, the mass flows also is quantized introducing Δ_q as smallest portion of product that can be held in a Δ_t time period. The whole amount M of product processed in a batch (e.g. a session or a working day) is divided in a number $n = M / \Delta_q$ of portions of product that will be individually tracked during the process. To each i-th portion of product, two state variables $T_i(k)$ and $p_i(k)$ are associated. $T_i(k)$ represents temperature, while $p_i(k)$ accounts for the node where the i-th lot of product is stored at time instant k.

The simulation of the plant can be carried on at two different levels of detail: a low level, where individual masses (portions) of product are singularly tracked and described and a high level, where a fluid approximation of the process is considered. In this case average or cumulative entities only, like the delivery of a pipe, the mass of product stored in a node, the mean temperature of the product in a tank etc. are considered.

The flow in a specific section of the plant is expressed by $\dot{m}(k)\Delta_q$ and represents the amount of product (kg) that flows in a Δt time period through the considered section.

In the follow, models of basic node, that will be combined and used to describe complex plants, are introduced.

Buffer tank

Consider, as a basic modelling element, the very simple discontinuous-flow node depicted in figure 1. It is constituted by a tank with an incoming stream $\dot{m}_1(k)\Delta_q$ and an outgoing flow $\dot{m}_2(k)\Delta_q\, q_2(k)$. The signal $q_2(k) \in \{0,1\}$ accounts for on-off state of the valve at time instant k, while $\dot{m}_2(k)\Delta_q$ represents the flow rate through the valve.

The high level mass balance of the node can be expressed as

$$\overline{M}_a(k+1) = \overline{M}_a(k) + (\dot{m}_1(k) - \dot{m}_2(k)q_2(k))\Delta_q \qquad (1)$$

where the state variable $\overline{M}_a(k)$ represents the mass of product stored in the node.

The flow rate $\dot{m}_2(k)\Delta_q$ can be expressed as

$$\dot{m}_2(k)\Delta_q = \begin{cases} 0 & \text{if } \overline{M}_a(k) = 0 \\ \overline{M}_a(k) & \text{if } \overline{M}_a(k) \le v_2(k)\Delta_q \\ v_2(k)\Delta_q & \text{if } \overline{M}_a(k) > v_2(k)\Delta_q \end{cases} \qquad (2)$$

where $v_2(k)\,\Delta_q$ is the nominal flow rate that can be either measured directly on the plant (e.g. with a flow-meter) or estimated, using, for example, overall mass-balances. Equation (2) takes into account the fact that, if the tank is empty (i.e. $\overline{M}_a(k) = 0$) then the flow $\dot{m}_a(k)\Delta_q q_a(k)$ is equal to zero, even if the valve is open (i.e. $q_2(k) = 1$).

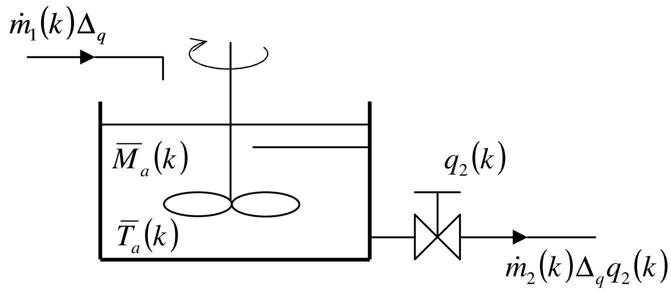

Figure 1. A simple stirred tank model

Analyzing the system from low level point of view, the permanence time of the product in this node cannot be exactly determined since new incoming product is continuously mixed with already stored product, so that it became undistinguishable. Permanence time can be estimated only in a stochastic sense, determining, for example, its average value. The approach proposed in this paper consists of modelling the tank as a First-In First-Out (FIFO) queue (see figure 2) where each element of the queue is constituted by a mass Δ_q of product and the server performs the simple task of deliver product at $\dot{m}_2(k)\Delta_q q_2(k)$ rate.

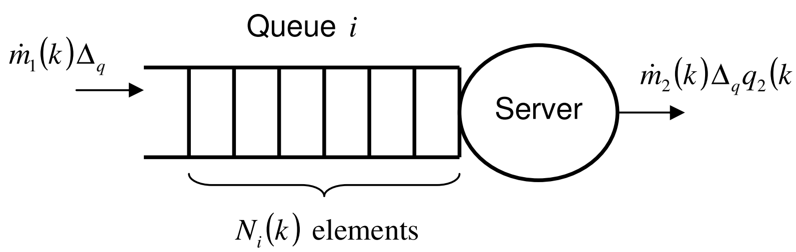

Figure 2. The queue model of a simple buffer tank

The service time of a specific portion Δ_q of mass of product represents its permanence time in the node. At each time instant k the position state $p_i(k)$ of all masses are updated by the queues.

The number of mass elements in the i-th node is $N_i(k)=\sum_{j=1}^{n}\delta_k\left(p_j(k),i\right)$, where $\delta_k\left(p_j(k),i\right)$ is the Kronecker delta and is equal to 1 if $p_j(k)=i$, 0 otherwise. The mass $\overline{M}_i(k)$ at time instant k is $\overline{M}_i(k)=N_i(k)\Delta_q$, while the average temperature $\overline{T}_i(k)$ in the node is

$$\overline{T}_i(k+1)=\frac{\sum_{j=1}^{n}\delta_k\left(p_j(k),i\right)T_j(k)}{N_i(k)} \quad (3)$$

Since the product in the tank is continuously mixed, we assume that each new incoming mass Δ_q in the node achieves the thermal equilibrium in Δ_t time interval, i.e.

$$T_i(k)=\sum_{j=1}^{n}\delta_k\left(p_i(k),j\right)\overline{T}_j(k) \tag{4}$$

Rewriting $T_i(k+1)$ in a recursive form, combining equations (3) and (4), it results

$$T_i(k+1)=\frac{1}{N_{p_i(k)}(k)}T_i(k)+\frac{\sum_{j=1,\ j\neq i}^{n}T_j(k)\delta_k\left(p_j(k),p_i(k)\right)}{N_{p_i(k)}(k)} \tag{5}$$

Buffer tank with two incoming streams

Consider, for this case, a stirred tank with two incoming streams $\dot{m}_1(k)\Delta_q$ and $\dot{m}_2(k)\Delta_q$ and an outgoing flow $\dot{m}_3(k)\Delta_q\, q_3(k)$, as reported in figure 3. Again the signal $q_3(k)\in\{0,1\}$ accounts for on-off state of the valve.

The mass balance of the node simply modifies in

$$\overline{M}_a(k+1)=\overline{M}_a(k)+\left(\dot{m}_1(k)+\dot{m}_2(k)-\dot{m}_3(k)q_3(k)\right)\Delta_q \tag{6}$$

where the variable $\overline{M}_a(k)$ represents the mass of product stored in the node, where the flow rate $\dot{m}_3(k)\Delta_q$ can be expressed again as in (2). The temperature $\overline{T}_a(k)$ of any mass in the tank can be obtained as

$$\overline{T}_a(k+1)=\overline{T}_a(k)+\frac{\dot{m}_1(k)\Delta_q\left(\overline{T}_1(k)-\overline{T}_a(k)\right)+\dot{m}_2(k)\Delta_q\left(\overline{T}_2(k)-\overline{T}_a(k)\right)}{\overline{M}_a(k)+\dot{m}_1(k)\Delta_q+\dot{m}_2(k)\Delta_q} \tag{7}$$

Temperature of the single mass Δ_q can be obtained again using relation (4).

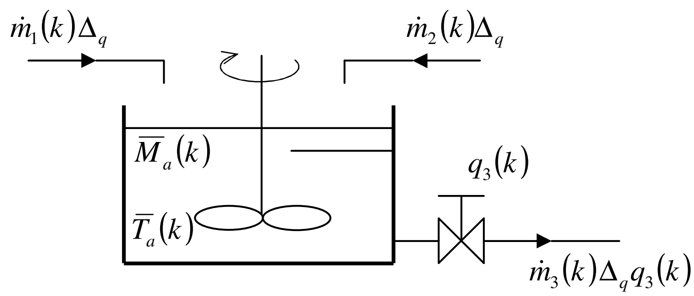

Figure 3. Model of a simple tank with two incoming streams

Two stirred tanks with an exchanging surface

This model structure can be used to represent simple heat exchangers where heat is exchanged by two fluids separated by a conductive wall. As can be seen in figure 4, this can be modelled by two simple tanks which are separated by a surface A through which a thermal flux ϕ, proportional to the heat transfer coefficient h, the difference of temperature in the two tanks and the surface itself A, is established. Mass balances are described rewriting equation (1) for each of the two tanks. At each time instant the temperature of each mass can be obtained according to the following procedure:

1. update the temperatures $\overline{T}_a(k)$ and $\overline{T}_b(k)$ of the tanks, considering the incoming streams $\dot{m}_1(k)\Delta_q$ and $\dot{m}_2(k)\Delta_q$ (see equation (3));
2. determine the thermal flow $\phi = hA\left(\overline{T}_a(k) - \overline{T}_b(k)\right)$
3. compute the temperatures $\overline{T}_a(k+1)$ and $\overline{T}_b(k+1)$ as

$$\overline{T}_a(k+1) = \overline{T}_a(k) - \frac{1}{\overline{M}_a C_{pa}}\phi\Delta_t, \quad \overline{T}_b(k+1) = \overline{T}_b(k) + \frac{1}{\overline{M}_b C_{pb}}\phi\Delta_t \tag{8}$$

   where C_{pa} and C_{pb} are the specific heat of the fluids in *a* and *b*;
4. determine the temperature of each mass contained in tank *a* and *b* (see equation (4)).

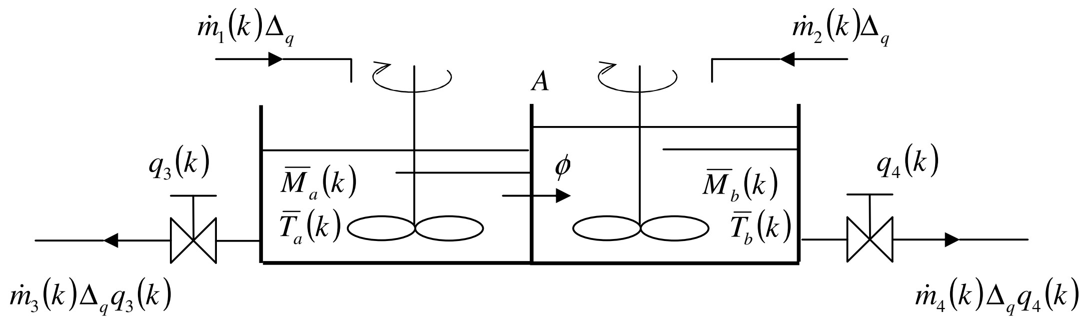

Figure 4. Two tanks with a thermal exchanging surface and incoming and outgoing streams

<u>*Continuous flow thermal exchanger*</u>

Continuous flow thermal exchangers, such as e.g. plate and tubular exchangers, can be approximated by a series of r simple exchangers, described in section 2.3. Figure 5 reports the scheme of a concurrent flow exchanger. Countercurrently flow exchanger can be analogously easily obtained. $\Delta\overline{T}_a(k)$ and $\Delta\overline{T}_b(k)$ represent temperature drops on each side of the exchanger, while $\dot{m}_a(k)\Delta_q q_a(k)$ and $\dot{m}_b(k)\Delta_q q_b(k)$ the flow rate of side a and b of the exchanger respectively. Temperatures can be obtained applying, for each stage, the procedure proposed in the previous section.

Fault diagnosis and detection

Aim of fault diagnosis methods is to individuate on-line the symptoms that indicate the beginning of a failure. This allows to foresee the fault recognition before the system breakdowns or, equivalently, the plant produces large amounts of unsatisfactory or unsafe product. Two distinct tasks can be performed: the detection of an abnormal behaviour of the plant and the individuation of the causes that have generated it.

The concept of a diagnostic system is constituted, as reported in figure 8, by a reference plant model which is used to generate, by simulation, estimated values that are adopted as reference output of a healthy plant. The difference between plant measured outputs and simulated reference outputs, performed by algebraic subtraction, provides the input for the diagnostic and fault detection modules. The simplest way to detect an abnormal behaviour consists of the evaluation, by means of statistical indicators, of the result of the subtraction. More sophisticate approaches have been presented in literature to detect a fault and to determine the causes (see e.g. Grimmelius et al, 1995). In this context, plant failures (e.g. a clogged up valve) are seen as additional inputs to the system. To guarantee that a specific plant failure could be detected from the system output, some conditions on controllability and observability properties of the system have to be satysfied.

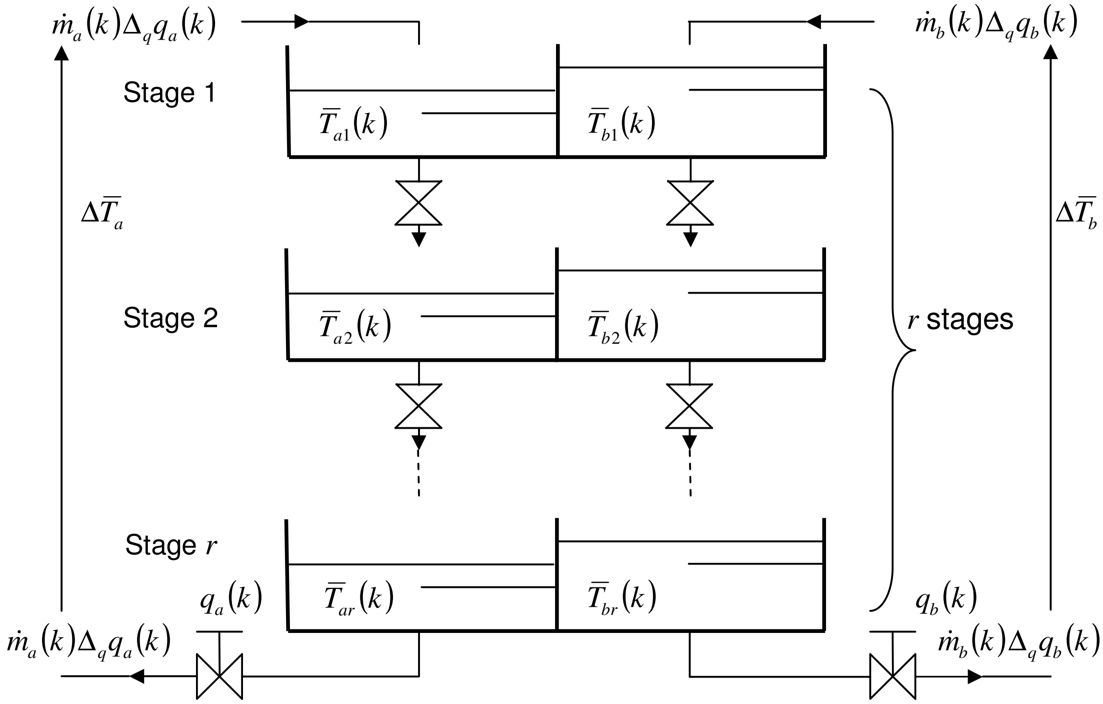

Figure 5. Model of a (continuous-flow) thermal exchanger

Conclusions

In this paper the problem of modelling and monitoring an industrial food process has been addressed. The proposed modelling methodology allows to cope with the case of discontinuous-flow plant which, to the best knowledge of the authors, have not been yet handled in literature, although most part of food plant operates in this condition. As discussed in the paper, a reliable model is the key element for fault detection systems that are able to early detect any plant failure that could compromise food safety and lead to quality breakdown.

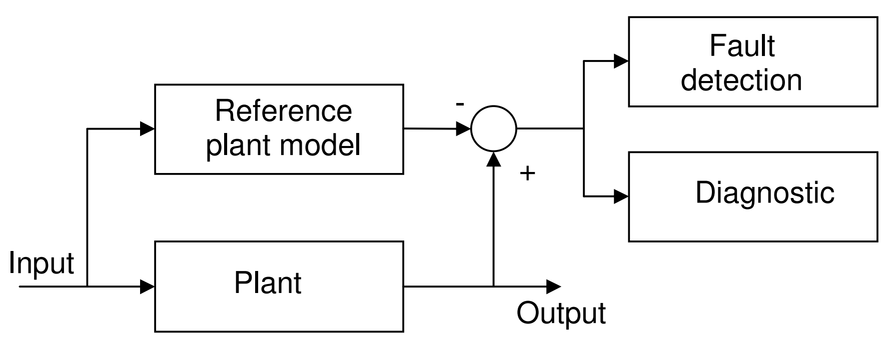

Figure 6. On-line fault detection and diagnosis

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Information technology for meat supply chain traceability

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Abstract

Technical features of RFID technology were tested with the aim of the implementation in traceability system with automatic data capture of identified animals.
Area of detection of two antennas of different size were described and reading performance when multiple tags are present in the reading area were compared. The feasibility of implementing a RFID system for the identification of small animals like piglets at weaning was evaluated by on-farm trials.

Keywords: traceability, RFID, farm management.

Introduction

The fulfillment of mandatory traceability as well as the increasing consumers demand of safety and quality information about products has led to the need, for each food product, to be followed by an increasing amount of data during the whole supply chain.

For meat, due to several sanitary crisis, breeders as well as slaughterhouses, are requested to collect and store different kinds of information. For example for cattle, in Italy, data regard: individuals identification and registration in the national register, mandatory sanitary data collected by sanitary officers and stored in official databases, other sanitary data that must be kept by the farmer, breed registers data and mandatory and voluntary traceability data.

Information is stored in different databases or manually written. Often there is no sharing of data among different databases.

The storage of all this information with this system is very time consuming and increases production costs.

The availability of automatic data collection could increase competitiveness of the meat supply chain as well as the reliability of the traced information.

Automatic identification by RFID coupled to other data capture systems as for example bar code reading are proposed for the automation of the data collection while electronic data interchange (EDI) should be adopted to reduce multiple collection of the same data along the whole meat chain. This implies a good integration of all the chain stakeholders which is fundamental to increase reliability and achieve more rational systems.

Moreover, as supply chains involve often stakeholders in different countries, a good interrelation among the information at international level should be achieved.

Animal identification RFID systems were envisaged in past years through many international research programs and ISO standard were established in the early year 1996 which adopted the frequency of 134 kHz for animal identification. In the European Union this standard has been chosen for mandatory identification of sheep and goats (starting from 1st January 2010) and for voluntary identification of beef cattle.

However, techniques based on ISO standard which were mainly developed for beef cattle, can raise some problems for use on other species.

Our work is aimed to find the best technical features needed for RFID animal identification systems in the breeding farms in Piedmont region and to evaluate some possibilities of automating also data collection of non-mandatory data for voluntary traceability and farm management.

In particular some limits of the passive, low frequency, identification technique were defined for pigs and cattle identification.

Materials and methods

The research was carried out in laboratory as well on living animals.

Reading performances of different types of transponders were determined by two different static readers.

Static readers were: reader E, an Edit-ID, Auckland, New Zealand panel antenna (850 mm x 650 x 45 mm, fig. 1) and reader G, a Gallagher Smart-reader (600 mm x 400 mm x 50 mm, fig. 2).

Figure 1. Reader E panel

Figure 2. Reader G panel

The system were both ISO 11784/11785 compliant, reading both HDX and FDX-B tags.

In laboratory tests the reading area of the two panels were compared in different tag orientations (parallel, null and radial orientation). A section of the reading volume in front of the antenna was estimated at half height of the antenna following a plan perpendicular to the antenna.

Reading area was determined for each tag type.

Dynamic laboratory readings were performed by a trolley simulating piglets movements and reading errors due to tag collision were defined. Readings were performed mounting on the trolley different tags at increasing distance with a defined speed and along a straight trajectory in front of the antenna at defined distances.

The trolley speed was constant ranging from 0.8 to 3 m/s. Number of readings were counted during the passage in front of the antenna for a 2 m path and reading share of the different tags was calculated.

In a close-cycle pig farm 315 piglets were identified by an ear-tag . The lot was divided in four sub-lot of piglets which were tagged with a different type of transponder. HDX and FDX-B button tag of different types (tab. 1) were applied to the right ear of the piglet using the apposite tagger plier. Piglets were tagged at weaning, day 21 and readings were performed on the same day by two different static readers.

As reading performance at passage widths which allow the passage of more than one piglet at a time resulted to give very poor reading performances (Gay et al., 2007), a 20 cm width passage was adopted for both antennas.

Dynamic reading efficiency (DRE %) was calculated according to Caja et al., 1999 (DRE% = devices which have been read/readable transponder present*100).

Table 1. Features of the electronic eartags tested in laboratory, applied to piglets.

	Brand	**Model**		**Diameter (mm)**		**Weight (g)**
				female	male	
A	Allflex	V3 LW	HDX	26.4	28.0	5.90
B	Allflex	LW	FDX-B	26.4	28.0	5.90
C	Caisley	Multiflex	FDX-B	30.0	27.5	7.55
D	Hauptner & Herberholz	Neoflex	FDX-B	26.0	30.0	5.30

Results

<u>*Antenna reading area*</u>

A section of the reading area at half height of the antenna is reported in fig. 3 for both readers in the parallel orientation (angle between antenna coil and tag coil 0°) and the radial orientation (the tag was oriented to the centre of the antenna).

As could be seen the smaller panel have a smaller area. Due to the small dimension of piglets a smaller area of detection should result in reduced problem of tag collision as a smaller number of piglets should remain in the detection field.

In tab. 2 are reported the detection area of the two antennas, calculated by an apposite software, with respect to the four type of transponder. As stated in literature, the detection area was smaller in the case of smaller tags and, in case of equal dimensions but different protocols (tag A and B) area was smaller for HDX transponder.

Area of detection of reader G was normally smaller than that of reader E for the different type of transponder.

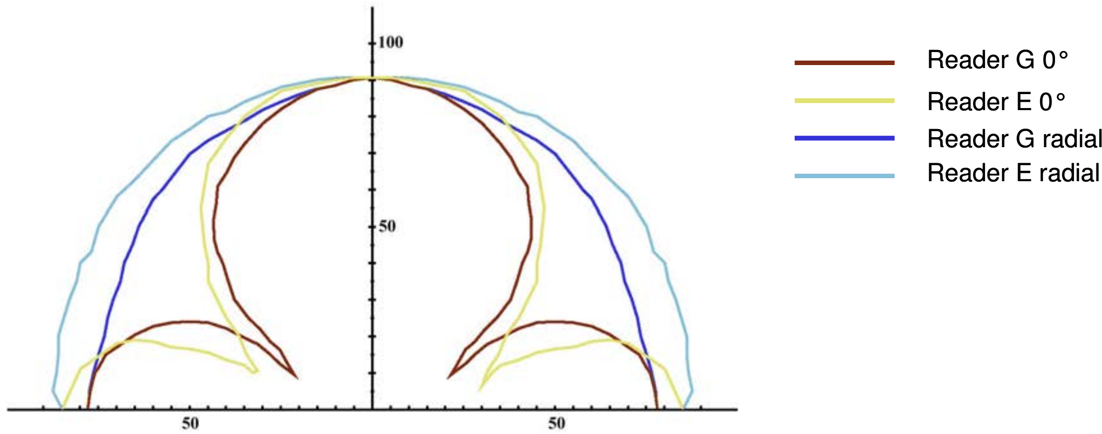

Figure 3. Antenna reading area comparison example. Area were determined using the two antennas and tag C in different orientations (see legend)

Table 2. Area of detection (cm^2) of the two panel readers determined by the four types of tag.

Orientation	radial		0°		90°	
Reader	E	G	E	G	E	G
Tag						
A	6584.8	5888.6	5565.5	5450.9	5777.6	5020.0
B	7857.5	8362.9	6132.9	6690.0	6409.5	6167.0
C	11218.4	10277.8	8627.2	8081.9	8083.0	7875.0
D	7696.0	8148.0	5758.1	5880.6	5776.0	5772.5

Dynamic reading performances of multiple transponders

Reading performance of different transponder in the reading area of the antenna was determined mounting on the trolley firstly only two transponder in all the combinations of the different type of tags mounted at increasing distance.

At small distances only one tag is detected if the two tags are both FDX while in the case of the presence of one FDX tag and one HDX tag, the two tags could be detected even if in contact (fig. 4 and 5). This situation occurred in each combination of a FDX and a HDX transponder Tag C had the best rate of detection when paired with tag B and D. Tag D was the less favoured as was not favoured when paired to tag B.

When distance among the two tags was increased, both tags were detected and a good share of both tags was obtained above 30 cm distance.

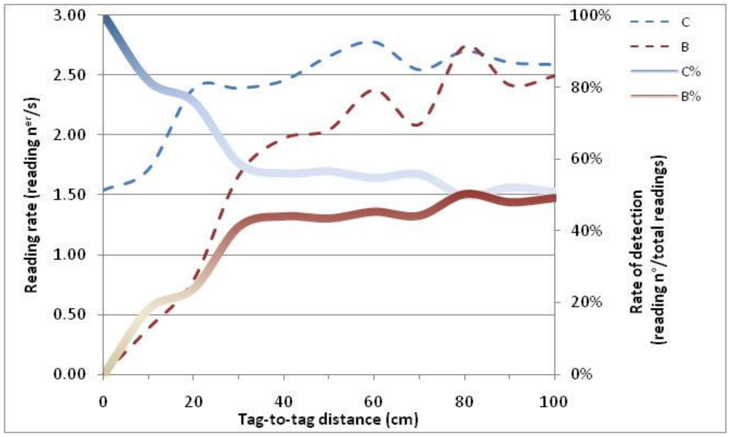

Figure 4. Reading rate and rate of detection of two FDX-B tags mounted at increasing distance

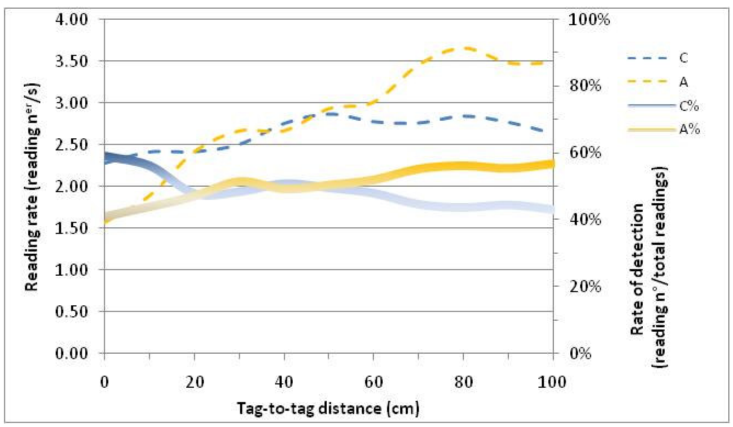

Figure 5. Reading rate and rate of detection of one FDX-B tag (C) and one HDX tag (A) mounted at increasing distance

Then, four transponder of the same type were mounted on the trolley at increasing distances. This is the situation that more often occurs in the farms as usually breeders tend to buy tag of the same brand. In Fig. 6, 7, 8 and 9 shares of detection of the four tags are reported, different colours meaning tag of the same brand but with different codes.

In all cases two of the four transponder have almost all the share of readings and, analyzing the code of the transponder and the order in the series we have noticed that these were the first and the last tag to pass in front of the antenna. These two tags, in fact, remain for a short time in the area of detection without interference with other transponders. The second and third positions were the less favoured at reading.

In the case of four HDX tags only three of the four transponders were detected.

In any case less favoured transponders were detected only if placed at a minimum distance of 20 cm.

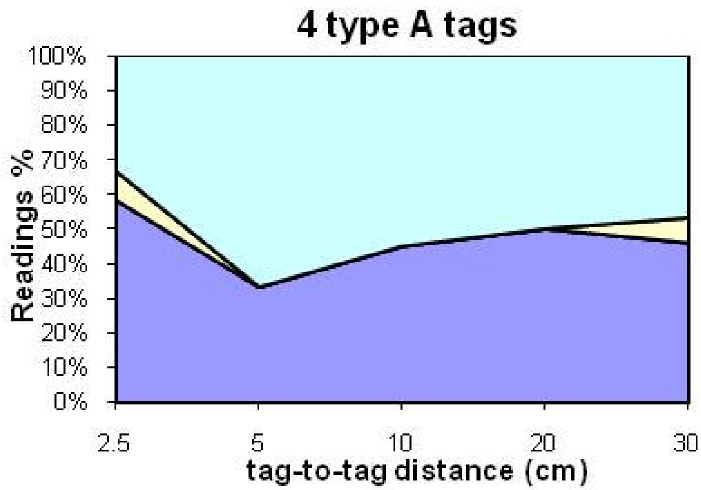

Figure 6. Shares of detection of four transponders type A

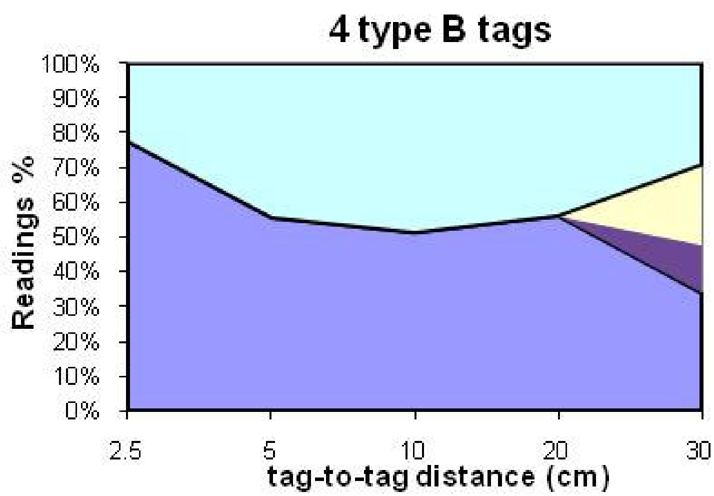

Figure 7. Shares of detection of four transponders type B

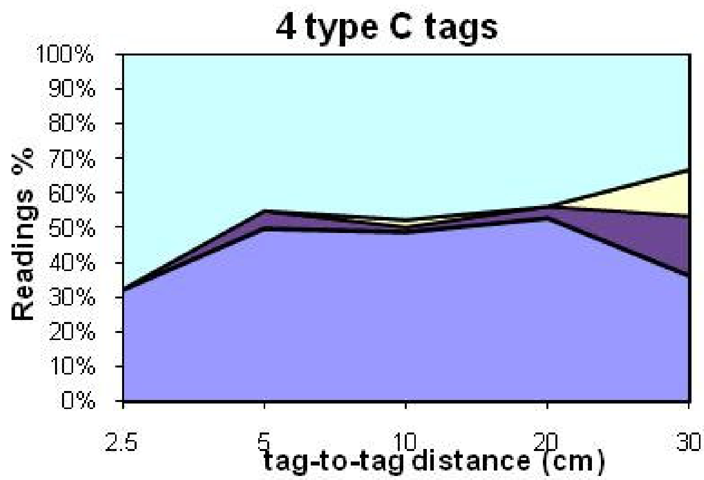

Figure 8. Shares of detection of four transponders type C

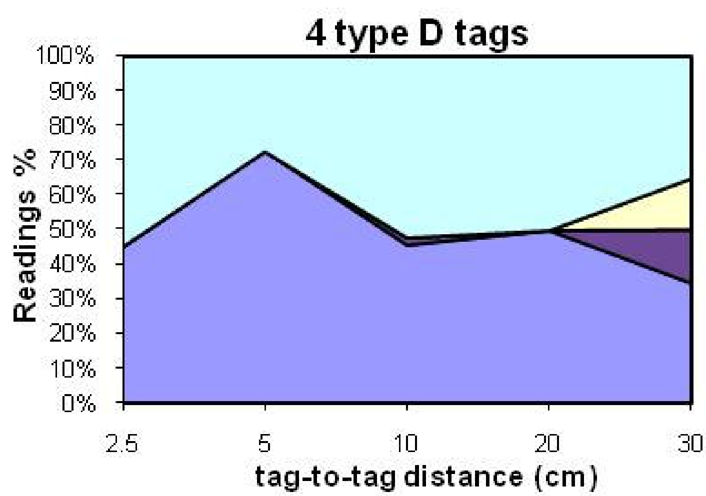

Figure 9. Shares of detection of four transponders type D

In all the above figures different colours represent tag of the same brand but with different code.

<u>*Dynamic reading performances of transponders applied to piglets*</u>

When dynamic reading was performed on tagged piglets at weaning with a narrow passage (20 cm) a dynamic reading efficiency of 85% was obtained with reader E, while in the case of reader G, the percentage of correct readings was higher and reached 95%. On the basis of laboratory data, the higher performance could be due to the smaller area of detection which could have avoided part of the transponders collisions (tab. 3).

Table 3. Dynamic reading performances of the two readers on the whole lot of piglets.

Reader	Transponder read	Readable transponders	DRE %
E	267	315	85
G	300	315	95

However, the reading of the whole lot of the piglets identified was not reached in both cases.

Conclusions

When an RFID system has to be integrated in a traceability system for animal identification, animal shape has to be related to reading area of the antenna and probability of collision among tags has to be considered.

The availability of information about the whole reading areas and of the dynamic reading performances are fundamental to integrate RFID systems in real traceability application. In the case of piglets or small animals like hens, where the collision problems are more severe, some authors have envisaged the use of HF RFID systems (Thurner and Wendl, 2007, Hessel et al., 2008) which could use anti-collision protocols. These systems could overcome the problems encountered in multiple reading of LF transponder but should be more widely tested and allowed for animal identification as, for example, HF transponders are nowadays not allowed for cattle, sheep and goats from the European Union.

Another way to solve the problem could be the use of antennas of smaller size and the synchronization of more than one antenna.

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TraceMEAT, RFID technology in the service of meat traceability

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Abstract

The aim of this work is to evaluate the feasibility of a reliable system for the traceability of carcass and beef, based on RFID technologies. As computer technology is increasingly employed in agricultural business, RFID (Radio Frequency Identification) will offer an efficient method of herd and individual animal management. Nevertheless such traceability isn't currently achievable during slaughtering, where products are identified by lots. RFID is a well-rounded technology if it is right conceived. To achieve this result, we base the research on the know-how of slaughtering process in Italy: we found out that there are different level of industrialization and productivity in slaughterhouse, having reference to two principal situations:A) high industrialized and high productivity abattoir; B) small abattoir. We had simulated a slaughter chain and compiled an animal database recalling the official National Cattle Database. We created and tested different RFID systems, from hardware and software point of view, which can be integrated in current processes, combining Low Frequency and High Frequency device and barcode. RFID technologies are suitable to be implemented in the slaughterhouse. The implementation of an RFID system in the abattoir slashes human errors, favours automation of the process and enables traceability of single carcasses. It's important to customize the system according to the specific process of any single slaughterhouse. Although High Frequency is suitable to be integrated in labels at the end of the process, Low Frequency assures best performances along the slaughter chain, cause it is less disturbed by electromagnetic interferences.

Keywords: Electronic identification, food safety, slaughterhouse, beef.

Introduction

With an increasing demand for security and safety, complete documentations for food products, from field to customer, have become increasingly demanding (Thysen, 2000).

Following the instability in the market in beef and beef products caused by the bovine spongiform encephalopathy crisis, the improvement in the transparency of the conditions for the production and marketing of the products concerned, particularly as regards traceability, has exerted a positive influence on consumption of beef.

In order to maintain and strengthen the confidence of consumers in beef and to avoid misleading them, it is necessary to develop the framework in which the information is made available to consumers by sufficient and clear labelling of the product (Reg. EC n. 1760/2000).

In order to ensure the safety of food, it is necessary to consider all aspects of the food production chain as a continuum because each element may have a potential impact on food safety.

RFID has been accepted as a new technology for a well-structured traceability system on data collecting, and human, animal and product tracking (Sahin et al., 2002).

Many wide national and international projects for livestock EID (Electronic IDentification), particularly about ruminants have been successfully completed. RFID is beginning to be used in a number of countries for tracing individual animals (mainly cattle) from birth to the processing plant. The key to individual animal traceability lies in the ability to transfer animal information sequentially and accurately to sub-parts of the animal during production. RFID-based tracking systems provide an automated method of contributing significantly to that information exchange (Mennecke & Townsend, 2005).

RFID is one of the many automatic identification technologies (a group which includes also barcodes) and offers a number of potential benefits to the meat production, distribution and retail chain too. These include traceability, inventory management, labour saving costs, security and promotion of quality and safety (Mousavi, Sarhavi, Lenk, & Fawcett, 2002). Prevention of product recalls is also considered an important role of RFID technology (Kumar & Budin, 2006). RFID technology has been available for approximately 40 years although it's broad application to packaging is a relatively recent development.

Common RFID frequencies range from low (125 kHz) to UHF (850–900 MHz) and microwave frequencies (2.45 GHz). Lower frequency tags (also named "transponders") use less power and are better able to penetrate objects. These tags are most appropriate for use with meat products, particularly where the tags might be obscured by the meat itself and are ideal for close-range scanning of objects with high water content (Kerry, O'Grady & Hogan, 2006).

Materials and methods

RFID is a well-rounded technology if it is rightly conceived. To achieve this result, we have considered transponder features, slaughering process and the needs of final users.

RFID transponder can be passive or active. In this study we only use passive one. Passive transponders have no battery of their own but contain a capacitor which is charged inductively or radiatively by transmissions from the scanner, and they use the stored energy to transmit their unique alphanumeric code on an appropriate frequency. Having no battery, these tags have unlimited endurance, but the range at which they can be detected is extremely limited (centimetres to a few metres at most) (Reynolds & Riley, 2002)

We checked on the know-how of slaughtering process in Italy: we found out that there are different level of industrialization and productivity in slaughterhouse, referencing to two main situations:

A) High industrialized and high productivity abattoir, with more than 30 employees, with first and second cut laboratory outbuilding; they process about 300 bovines/h.

B) Small abattoir, with less than 10 employees; they process less than 80 bovines/d, 3 days for week. They directly send out half-carcass directly, without cutting.

We had simulated a slaughter chain and compiled an animal database recalling the official National Cattle Database. We created and tested different RFID systems, from hardware and software point of view, which can be integrated in current processes, combining Low Frequency and High Frequency device and barcode.

We created two different user interfaces, one for each case (A and B). We checked on the usability of these interfaces, particularly for case B, testing the system with 10 users scarcely skilled in technology.

Although this tracking scheme is for quality control purpose, employee accountability and precision cutting, and does not extend beyond the cutting room floor or provide information about the individual animal with the final product, it does exemplify the developing use of RFID technology within the meat industry (Kerry, O'Grady & Hogan, 2006).

We finally investigated on what is provided for beef labelling by the European Union. The label shall contain the following indications:

(a) a reference number or reference code ensuring the link between the meat and the animal or animals;

(b) the approval number of the slaughterhouse at which the animal or group of animals was slaughtered and the Member State or third country in which the slaughterhouse is established;

(c) the approval number of the cutting hall which performed the cutting operation on the carcass or group of carcases and the Member State or third country in which the hall is established (Reg. EC n. 1760/2000).

CASE A (fig 1)

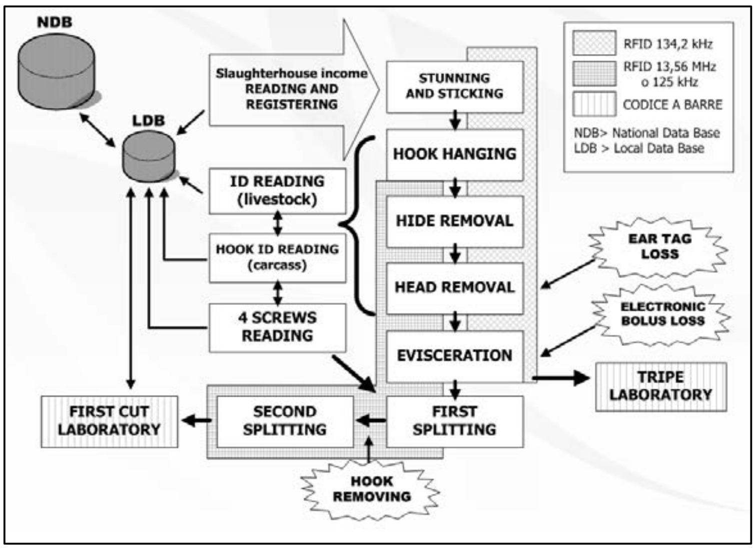

Figure 1. The scheme represent an RFID system in all steps of the slaughter process. Critical points where the identity can be lost are underlined in the figure

The animal (X), electronically identified by a bolus (fig 2) or an ear-tag (fig 2), enters in the abattoir and it is read by an ISO 11785/11785 controller and antenna. This code is compared with that one recorded on the National Data Base, and so it is possible to ensure if every information is correctly stored in each field of this DB.

Before this ID is removed from the carcass, its code is matched with the one of the hook on which the carcass hangs H(X). To do that hooks are pre-emptively identified with an HF (High Frequency) ISO 15693 tags.

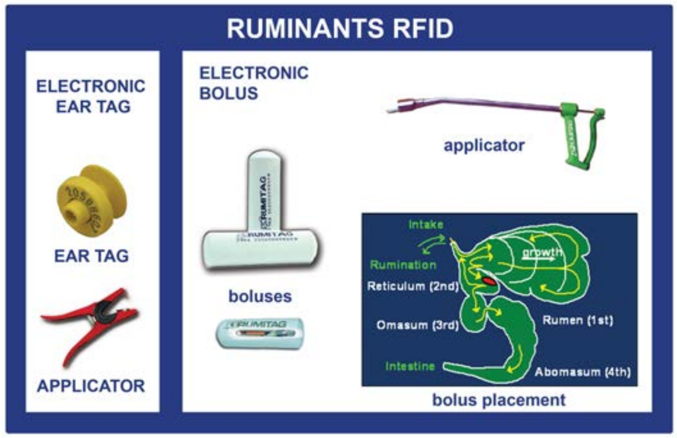

Figure 2. Transponders for electronica animal identification and their applicators

Along the slaughtering, before the carcass is removed from H(X), its ID is matched with the ID code of four electronic screws, each one of them put on a quarter of beef. Each quarter gets to the first cut laboratory where, thanks to the reading of the screw, some conventional paper labels are printed; each printed label contains all the informations about the animal origin, obtained from the local database, combined with those required by EU legislation, related to the slaughterhouse and first cut plant. The quantity of labels printed depends on the number of cuts related to the single carcass. The whole process is managed by a single controller and each step is visible and verifiable through a web interface (Fig 4).

Figure 3. Esempio di etichetta stampata nel caso A

GATE INGRESSO					
	Codice Anagrafe	Bolo	Razza	Origine allevamento	Ora ingresso in macello
	FR0340006523 42	983040000019221	BLONDE D'AQUITAINE/GARONNESE	AZ. LILLE	27/07/2006 17:46:15

GATE 2						
	Codice Anagrafe	Bolo	Razza	Origine allevamento	Tag Gancio	Ora Abbinamento con Gancio
	FR034000652342	983040000019221	BLONDE D'AQUITAINE/GARONNESE	AZ. LILLE	3873AC00000104E0	27/07/2006 17:49:15

GATE 3						
	Codice Anagrafe	Bolo	Razza	Origine allevamento	Id Pin	Ora Abbinamento con Pin
	FR034000652342	983040000019221	BLONDE D'AQUITAINE/GARONNESE	AZ. LILLE	D0F59D07000104E0	27/07/2006 17:56:15
	FR034000652342	983040000019221	BLONDE D'AQUITAINE/GARONNESE	AZ. LILLE	59F59D07000104E0	27/07/2006 17:56:15
	FR034000652342	983040000019221	BLONDE D'AQUITAINE/GARONNESE	AZ. LILLE	8EFF9D07000104E0	27/07/2006 17:56:15
	FR034000652342	983040000019221	BLONDE D'AQUITAINE/GARONNESE	AZ. LILLE	3FF79D07000104E0	27/07/2006 17:56:15

Figure 4. Interface of the application in case A

CASE B

The animal (X), electronically identified by a bolus (fig 2) or an ear-tag (fig 2), enters in the abattoir and its identity (ID) is read. If the bovine is not identified with an electronic device, operators can manually enter the conventional code of the animal, taking from animal passport or conventional ear-tag. The system automatically verifies if the animal is correctly registered in the National Data Base, and in this case the operator can insert the number of label to print. In this system we use RFID labels, made by a special food paper and cointain an HF (High Frequency) ISO 15693 Tag. RFID labels do not influence meat colour more than traditional labelling system (Vorst, Clarke, Allison & Booren, 2004).

Figure 5. Esempio di etichetta stampata nel caso

Information about the animal origin, obtained from the local database, combined with those required by EU legislation, related to the slaughterhouse are written in three ways: visual, on a bi-dimensional barcode (standard PDF 417) and on the chip of the tag.

Printed labels are thrust upon the carcass, one for each quarter. For a correct stick of the label, it is important that the carcass is already hot.

We have tested the system (case B), in order to evaluate the "effectiveness, efficiency and work satisfaction of users to reach aims at concrete task and environment" id est to evaluate the "usability" of the system. (Ref. ISO 9241 'Ergonomic requirements for office work with visual display terminals (VDTs)', part 11). More in detail, the effectiveness of a system is the ability of the system itself to produce a desired amount of an effect, while its efficiency is the rate between the achieved results and the effort spent to reach them. We performed the usability study in the Usability and Accessibility Lab (Laboratorio di Usabilità ed Accessibilità – LUA) of CATTID and we've chosen 10 users scarcely skilled in technology, with any previous knowledge about RFID systems, in order to simulate the final target of the application (slaughterhouse operator). We provided them with a summary description of the RFID technology before starting the tests.

Figure 6. Example of one of the interface of the application in case B

Results

Both systems result efficient and reliable to guarantee traceability during slaughtering. Implementation in case A is more expensive but assures the traceback to the origin of the carcass in any point of the slaughter chain, also when more carcasses are contemporaneously cutted (sicura? che vuole dire?). The system in case B results suitable for small abattoir where operators work on one carcass at a time.

Although High Frequency is suitable to be integrated in labels at the end of the process, Low Frequency assures best performances along the slaughter chain, because it is less disturbed by electromagnetic interferences.

Usability studies conducted on the application revealed an high degree of effectiveness (all the users success to perform the assigned tasks) and of efficiency (the effort spent to reach the desired task was quite low). The users highlighted a good level of satisfaction, too. These parameters were estimated through the observation of the users while interacting with the prototype and through the analysis of the survey carried out to them.

Conclusions

RFID technologies are suitable to be implemented in the slaughterhouse. The implementation of an RFID system in the abattoir slashes human errors, favours automation of the process and enables traceability of single carcasses. It is important to customize the system according to the specific process of any single slaughterhouse. Although the implementation of intelligent packaging of meat products using RFID technology is still largely hypothetical, indications suggest it is unlikely to remain so for very much longer (Kerry, O'Grady & Hogan, 2006).

Growth of the RFID industry worldwide, driven by the development of technologies combining electronic article surveillance and bar code replacement systems, as well as by an increasing number of other applications is leading to smaller, 'smarter', but still inexpensive, passive transponders.

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POSTER PRESENTATION

Environmental and surface hygienic quality of small dairies in mountain areas: suggestion to improve food safety

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Abstract

This survey investigates the quality of the environment and any work surface (floors, walls, worktops) in small family-run dairies to identify frequently neglected critical factors, despite their potentially decisive role in improving the hygiene standards of dairy processing. The major problems of small dairies are related to the microbial contamination and the environmental conditions that are essential for quality cheese-making. Hygiene both in the environment and on the work surfaces is important to avoid microbial contamination, and if food-environment interactions are not monitored correctly, food safety can be at risk.
The choice of the sample fell upon family-run farms still characterized by craft work and traditional methods. In every dairy and in all processing premises, surveys were carried out to assess microbes and eumycetes role in air and work surface contamination. Air contamination was checked by means of a microbiological air sampler followed by colony count. The microbial surface contamination was determined by three different techniques (swab method, sponge method and bioluminescence method).
In general air quality appeared to be good. A small number of microbiological health indicators, found just outside the entrance to the dairy, were due to cross-contamination coming from the cattle- shed. In some cases work equipment surfaces revealed unsatisfactory hygienic conditions due to ineffective cleaning operations. In this respect we underline that it would be useful to use boiling whey especially in dairies where running water is not available.

Keywords: work equipment surface, microbial air contamination.

Introduction

To produce hygienically safe food, an environment clean and free from any source of contamination is essential. Even more care is needed in the case of handmade or craft products, exposed to air for a long time while being processed. An essential element to decrease microbial contamination of the product, is good quality of both the air and of the surfaces where this process occurs; this can be obtained by an adequate design of the premises followed by the adoption of correct hygienic procedures. It means that both the layout and the building must be apt to avoid or reduce filth settling and scattering and to facilitate cleaning; also periodical hygienic programmes will ensure constant cleaning. It is hard for dairies set in isolated areas, such as those in mountain areas, to keep a properly cleaned environment; this is due to the inadequacy of the premises to a thorough cleaning and to scarce availability of water. The aim of this survey was to examine the hygienic quality of production premises in small mountain dairies and to supply producers with practical suggestions for more hygienic procedures.

Material and methods

Several dairies located in different mountain areas, that is in the valley floor or on mountain pasture, were examined. Most of them were small sized, while some in the valley floor were medium sized.

On one hand, the smaller typology consists of family-run businesses where two people are involved, one with the breeding and the other with the cheese-making; or even where only one worker can conduct all activities, and - if necessary - other components of the family can help.

On the other hand, dairies in the valley floor may employ 4-5 workers. Equipment and plants there consist of several steel basins in case of natural milk skimming; of a small steel churn to make butter; of one or two gas or wood heated copper or steel vats; rarely of steam double layer vats; of steel or wooden tables to purge the whey; of food grade plastic or metal curd moulds; of plastic tanks for brine salting, and of wooden boards for cheese drying and ripening. The biggest dairies can also be provided with stainless steel tanks where to chill-storage milk; centrifuges for mechanical milk skimming; pasteurizing machines (raw milk is rarely used); machines for butter moulding and packaging, and plants for washing curd moulds.

Microbial air contamination

To check quality and quantity of air bacterial contamination it is necessary to sample microbial cells suspended in the air, to have them multiplied on proper culture media, counted on the plate, and following insulation to identify micro-organisms. It is a technique that highlights metabolically active micro-organisms, i.e. able to reproduce themselves and give shape to visible colonies; so data obtained might underestimate the real air contamination.

The equipment used was Microbial Air Monitoring System (Merck, mod. MAS-100 Eco®), a single-stage aspiration orthogonal impact sampler able to aspirate fixed air volumes. Within its head, to be sterilized before each sampling, there is a 90 mm Ø Petri dishes with a specific culture medium to collide with aspired air. The plates are stove-incubated according to time and temperatures depending on the microbial group searched. The air-dispersed microbial concentration is calculated as to the number of colonies developed, and to the volume of aspirated air.

Processing premises (skimming, cheese-making, ripening) were sampled in different points and at different heights. Each figure obtained derives at least from the mean of three samplings. They were performed while processing was in progress to consider its actual hygienic conditions. Obtained concentrations were compared with the European Community Board indications (*European Collaborative Action*) suggesting the following guiding levels of air contamination for indoor environment:

- Very low, for colony-forming units less than 50;
- Low, for colony-forming units between 50 and 100;
- Medium, for colony-forming units between 100 and 500;
- High, for colony-forming units over 500.

Work surface contamination

Two techniques were used to control work surface contamination: sponge and swap methods, both implying the development of vital micro-organisms on the plate. Bioluminescence was used when traditional microbiological analyses were not possible.

The sponge method required the use of small sponges inside sterile sealable bags containing some sterile diluent (100 ml triptone salt). Sampling consisted in passing a wellwrung sponge across a 10x10 cm surface to analyze. The sample obtained was refrigerated up to its analysis, to be performed within 24 hours. In the laboratory, decimal progressive dilutions of the sample were pour plated using different culture media. Plates were incubated at variable time and temperature in relation to the microbial group searched. Surface contamination (CFU/cm^2) was calculated according to the number of colonies grown on the plate, to the plated decimal dilution, and divided by the sampled surface.

The swap method was used when it was necessary to measure contamination on surfaces of difficult reach, e.g. pipes. Sterilized sticks with a cotton wool end were fit for the purpose. The surface to check for contamination was rubbed down with a stick dampened with triptone salt; the stick was then reinserted into the test tube and refrigerated up to its analysis, to be performed within 24 hours. In the laboratory, the content from the test tubes was spread plated. Plates were incubated at variable time and temperature in relation to the microbial group searched. The surface contamination value was given by the number of colonies grown per unit of sampled surface.

Bioluminescence technique was used to measure on the field the overall level of microbial contamination of the work surface. This method is based on the oxidation reaction between luciferine and ATP, which, catalysed by luciferase enzyme, in aerobe environment produces light. Such a technique measures total ATP deriving from microbes and others (remnant food, human and animal by-products). Therefore, bioluminescence outlines how clean a work surface can be as to microbes and non-microbial remnants that facilitate the growth of any micro-organisms.

A bioluminometer (Merck, mod. HY-LiTE® 2) and a sample kit were used. The methodology was based on the following steps:

- Sample taking using suitable kit;
- ATP reaction by luciferase enzyme;
- Instrument reading (within 10 seconds from reaction).

The instrument measures the light intensity emitted by obtained ATP reaction and gives results in RLU (Relative Light Unit). The result can be converted into CFU using a calibration straight line previously stated for surfaces whose contamination is given. Literature suggests standards that on one hand give values of microbial charge (aerobic mesophils) above which the surface denotes incorrect sanification; on the other hand threshold values above which there is risk of impairing the quality of the food in contact with the surface. Correct sanification of the surfaces is indicated by few CFU/ cm^2 , generally not over 50 CFU/cm^2 for mesophil aerobic bacterial charge, and 1 CFU/cm^2 for other indicators (*Enterococcus faecalis*). Instead, the highest values of microbial charge above which food quality is at risk, enhancing its deterioration, equal 10^4-10^5 CFU/cm^2.

The surfaces of milk skimming basins, vats, curd, tables to purge whey, and maturing boards, were checked before and after their cleaning, with the aim to verify the efficacy of sanification procedures.

Results

<u>Microbial air contamination</u>

Microbial surveys were performed inside milk skimming room, if any, cheese-making and ripening premises, and were repeated at least three times each sampling session, as well as in different periods, e.g. in spring and in winter. Microbial air contamination data, as seen in figure 1, represent mean values of air contamination from sampled dairies.

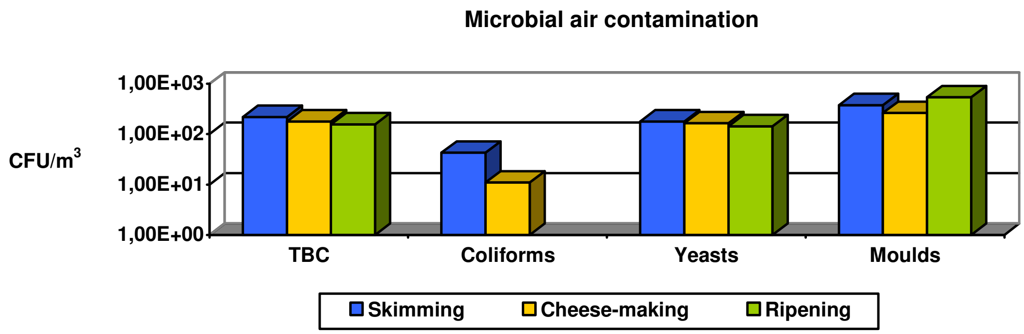


Figure 1. Mean values of microbial air contamination in the main work premises, expressed in colony-forming units per cubic metre of air

Measured values for TBC (Total Bacterial Count), yeasts, and moulds were slightly over 10^2 CFU/m^3, which indicated a mid-low contamination level, though not important.

Presence of Coliforms, about 10 CFU/m^3, called for more attention even if found in few dairies, as they indicated faecal contamination. They were localised in skimming and cheese-making premises. The cross-contamination of the processing premises came from the nearby cattle-shed or was due to the overlap between cheese-making and breeding operations performed without hygienic work procedures. On observing every single result obtained from each dairy, it is clear that contamination levels are different (Figure 2).

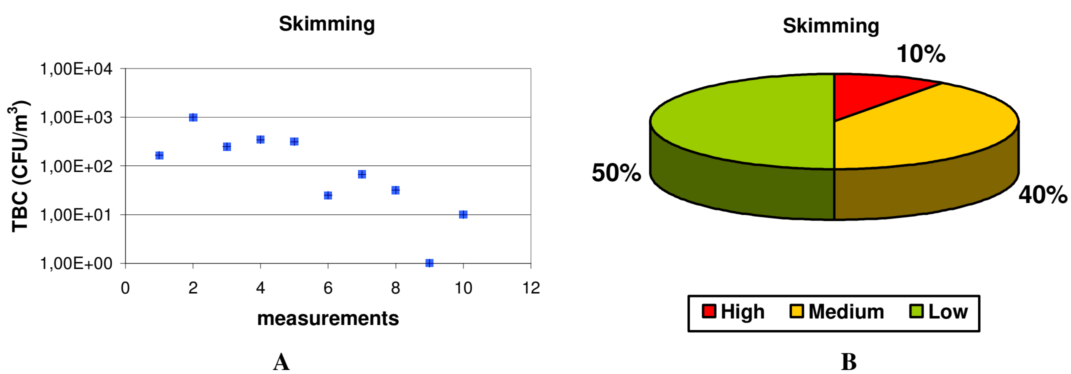
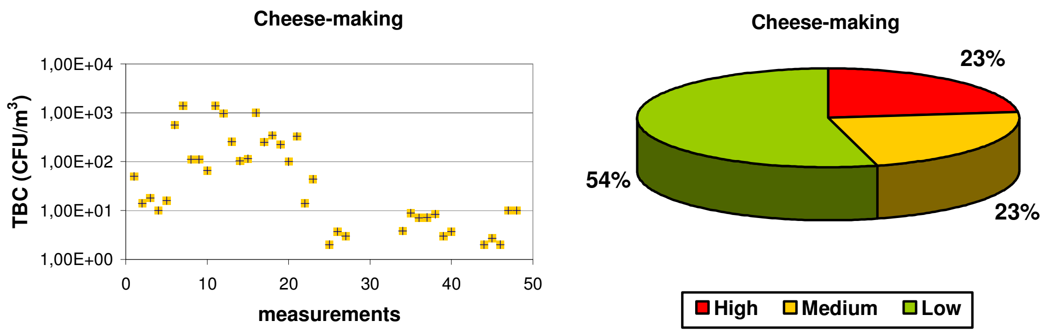


Figure 2. Air-dispersed microbial charge data obtained in skimming rooms (A) and percentage related to dairies considered according to their contamination levels (B)

10% of skimming rooms was clearly contaminated, with TBC being above 500 CFU/m^3, mainly due to structural and procedural reasons. Critical situations showed (i) windows without anti-insect nets or with nets so damaged to be unable to protect against flies and other insects transmitting faecal contamination; (ii) skimming room close to dirty rooms, or milk skimming basins set inside premises used for activities other than production; (iii) a filthy room because of frequent coming and going of workers carrying milk cans. Good air quality was anyway found in the other rooms, which is important to keep milk quality unaltered.

Similar situation was found in cheese-making premises (Figure 3).

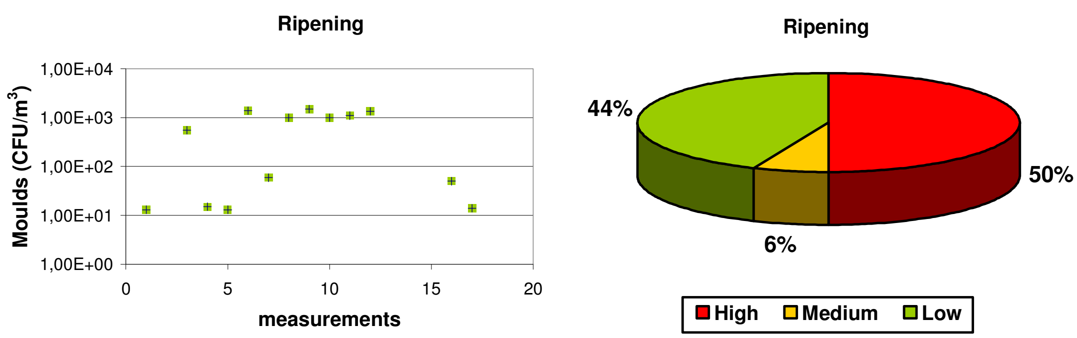


A B

Figure 3. Air-dispersed microbial charge data obtained in cheese-making rooms (A) and percentage related to dairies considered according to their contamination levels (B)

Total microbial charge (TBC) measured showed contrasting situations. In the most contaminated dairies (23%), contamination derived from the cattle-shed, then it was due to their casual layout and the state of neglected work premises, which made it hard to sanitize them also because no drinking water was available. Steady cleaning through deterging and sanification of the premises can improve the hygienic quality of the environment. For example, in a dairy whose environment was highly colonised by *Enterobacteriaceae*, their concentration was significantly decreased by simply foam washing its walls. From the details of our data, dairies in the valley floor generally resulted to be the dirtiest, being bigger and employing more workers who could spread contamination. It was also evident that workers who know hygienic procedures can determine a better environmental quality.

In the ripening rooms, moulds are the predominant microbial forms (Figure 4) and difference in concentration levels can be relevant in case of refrigerated cells or cellars.



A B

Figure 4. Air-dispersed microbial charge data obtained in ripening rooms (A) and percentage related to dairies considered according to their contamination levels (B)

Higher contamination was observed in cellars (50%), almost all equipped with wood maturing boards. It was mainly due to white or green moulds deriving from each product rind, moulds for which constant microclimate was an ideal habitat.

The peculiar flavour of the product is significantly determined by the presence of such moulds and their metabolic activity. A different situation was found in cells where the microbial charge resulted to be low (44%) and scarcely due to moulds and to trivial environmental saprophyte bacteria, mainly deriving from workers (cross-contamination) or from incorrect use of entrance doors.

Microbial surface contamination

Microbial charge on the surface of most tools used in cheese-making (milk skimming basins, vats, curd moulds, tables to purge whey and maturing boards) was measured as well as on the walls near the processing areas (Figure 5).

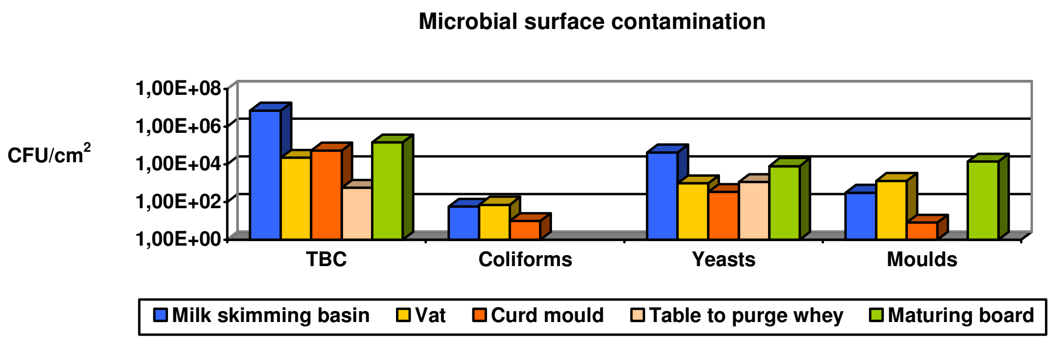


Figure 5. Mean values of microbial charge on main tools for cheese-making and ripening, expressed in colony-forming units per square centimetre

The milk skimming basins resulted to be the dirtiest, their measured values were always above 10^3 CFU/cm^2. This was probably due to their being washed with only cold water, sometimes high pressured. In fact, only few dairies used detergents. If water for washing was highly contaminated, basins resulted contaminated too as a consequence. Residual microbial charge could develop as basins were let to dry naturally.

As for vats, lower values were measured, and no particular difference was noted between copper and steel vats. Surface hygiene was highly dependent on washing procedures. The vats where hot whey was used were generally perfectly clean, which could not be obtained by only water-washing.

A similar situation was found for curd moulds. They were usually washed with water and detergents or sanitized in acid solution at 70°C followed by an alkaline treatment. If moulds were not kept in clean places or simply watered with tap water after their use, surface microbial charge reached values between 10^3-10^5 CFU/cm^2.

Tables to purge whey as well as boards for cheese ripening were clean thanks to the bactericide action of the acid whey. Wood is usually considered a scarcely hygienic material; actually, when brushed to be cleaned it is less contaminated than other surfaces. Replacing tiled walls improved hygiene level (TBC lower than 10 CFU/cm^2) when compared with those obtained by periodical cleaning of the walls (once a week or every 2 weeks). Highest values were shown at dairies where air contamination was moderate.

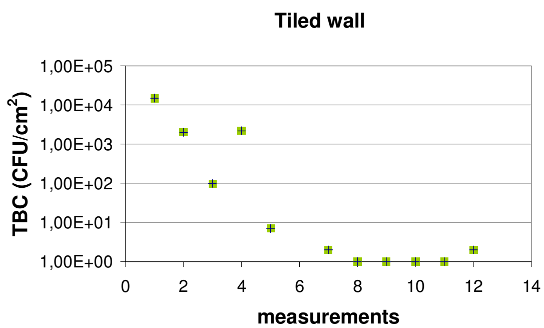


Figure 6. Surface microbial charge from walls, expressed in colony-forming units per square centimetre

Conclusions

From a microbiological point of view the quality of processing premises was generally satisfactory; this mainly in small alpine pasture environment, for which objective difficulties were to be considered. No pathogenic forms (*Listeria monocytogenes* and *Salmonella* sp.) were detected, which is extremely positive. To assure proper uncontaminated air, particular care is necessary as to the location of doors and to the closing and protection of windows; moreover, access to the premises is to be limited only to the staff.

One main critical factor consists in water availability for cheese-making and for washing. In many situations mains water is not available, so surface water must be treated. Such an operation supplies microbiologically acceptable water at first, but its characteristics cannot be kept for long, which implies increased contamination of the surfaces. In such a case, hygiene can be ensured by the use of boiling water to clean milk skimming basins and other various tools and by promptly drying them with clean cloths, while whey could be used for vats.

As to ripening premises, cellars can affect the typical characteristics of cheese positively, while cold stores can alter the environmental ecosystem because of tiles, PVC, and stainless steel surfaces, thus contrasting the development of all the sensorial peculiarities so important to make a craft product unique.

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Safety food in olive oil supply chain

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Abstract

The agro-food sector has been hit by scandals and frauds in the last few years. This has resulted in a growing interest in notions including quality, food safety and foodstuff origin on the part of consumers.

In order to guarantee the safety of food products all the elements of the food production chain should be considered as one only process from primary production down to sale or supply of food products to end consumers in view of the impact that each element of this chain is likely to have on food safety. Traceability and food safety are therefore becoming key concepts to increase produce competitiveness as well as consumer acceptance. A completely different approach to the problem, as highlighted by the above examples, suggests to utilize, for the time being, the definition given by the Italian "Academy of Georgofili: "Chain traceability means identifying all the businesses contributing to the production of a food product. Such identification relies on monitoring the flows of materials 'from farm to fork", i.e. from the producer of the raw material to the end consumer" (Georgofili, 2000).

The present work is focused on the analysis and on the use of systems of traceability in the olive growing/olive oil production and supply chain of an Italian Region: Calabria.

Keywords: safety, tracking, tracing, olive tree, dynamic lot.

Introduction

For guaranteeing the safety of all food products all the aspects of the channel of food production should be considered as a one only process which starts from primary production and ends to either sale or supply of food products to the consumer passing through a number of processing steps which may all have a role in terms of food safety (Hernández, 2003).

Food traceability and safety are becoming notions crucial to those who work in this sector as they are likely to increase produce competitiveness and appreciation on the part of consumers.

The study carried out has been intended to detect any mismatches, i.e. errors of manipulation or of registration likely to compromise the identification of the product traced in a view to suppressing any sources of risk in compliance with the requirements of EC Reg. 178/2002.

The work, therefore, is focused on the analysis and the use of both tracking and tracing systems of olive and olive oil products. The present study has been based on an in-depth analysis of the area under consideration in a view to identifying some farms typical of the territory in question. The different steps of olive processing have been analyzed, from olive harvesting to olive processing at the oil mill.

Materials and methods

To implement the 'better practice' traceability model in a single company, or even in a single chain, is not too difficult, but it is a much bigger challenge to influence a whole chain, or even an entire industry.

For the food industry as a whole, the distance between the 'actual' state and the 'desired' state is huge, especially considering the diversity of the products, chains and actors.

Unique batch identification in the real sense of the word is not widespread, advanced use of barcodes (for identification, not data carrying in general) is neither widespread nor standardised, and radio-frequency tags are certainly not common. Adapting the technical innovations is one thing, but the organisational challenges are much greater.

The good manufacturing practices is widely adopted in the food industry, but unfortunately not a good traceability practices. It is common to carefully take care of and check the raw material or ingredient that you receive, but rare to do similar with the information pertaining to it.

Numerous studies have shown that the information loss from one link in the chain to the next is huge, in some industries documented to be 80-95% (Storoy, Foras, & Elsen, 2007).

In the current situation, the buyers of food products normally specify the structure and content of the information that is transmitted, often through lengthy forms to be filled out by the supplier. The supplier then has a wide variety of forms to fill out, with conflicting names and measurements.

By using a standard, information becomes re-usable and unambiguous, and workload is minimized. Suppliers can deliver information in one format and buyers can receive information the same format.

A language for standardized electronic communication has been developed especially.

A detailed analysis of the productive processes has been carried out relying on the so-called "dynamic lot", defined as the unit of product processed (either directly or indirectly) in a unit of time (usually one day), as a function of the specific features of the farms in question (orographic features, level of mechanization, etc.).

The study has been initially focused on the study of the most widespread olive cultivars in the area under consideration.

The survey conducted has highlighted that olive growing accounts for the move important sector (in terms of production) of the farming economy of the Region Calabria.

The commonest cultivars of Calabria, object of this work, are: *Ottobratica*, *Sinopolese*, *Carolea*. Such varieties (figures 1,2,3) account for 76% of the regional olive growing heritage (Sciarrone, Abenavoli, 2006).

Figure 1. Olive trees cv *Ottobratica*

Figure 2. Olive trees cv *Sinopolese*

Figure 3. Olive trees cv *Carolea*

On the basis of the above remarks, the present study has focused on the definition of a logistic unit (the lot) as an initial unit of reference for all infield cropping operations, harvest included. On the grounds of the results of a three-year a research effort a correlation model (which is being finalized) has been defined which is intended to determine on a quantitative basis (surface) the lot containing the most important data that accompany the production process, from the olive grove to the oil mill.

Given the heterogeneous nature of the olive growing sector under study, the determination of the *dynamic lot* (L_d) can depend on the following variables:

$$L_d = f(i, t_i, s, c, M_a, O_l)$$

where:
i = soil slope;
t_i = planting typology;
s = shape and layout of the groves;
c = plant size;
M_a = level of mechanization;
O_l = level of organization of the work site.

The parameters contained in the equation spell out the peculiarities of the olive grove under consideration. As a result, also the size of the lot will necessarily vary and its dimensions will be determined case by case.

Results and conclusions

The primary objective of the present study has been the detection of any mismatches, i.e. handling or registration errors likely to impair the tracking of the product in question. When these errors occur the portion or the lot of product in question must be excluded not only from the traceability line, but also from the food chain to suppress any sources of risk in compliance with EC Reg. 178/2002 articles 3, 6, 7, 8 (Reg. 178, 2002).

Documentability has been obtained by means of a precise description of the productive process and of the control systems together with the indication of the procedures which define the operational procedures of the production process under consideration.

The reliability of the mathematical model used for the determination of the lot described in the previous sections has been tested on the basis of the data collected during the three-year period 2004-2006 at the olive growing farms under study. More specifically, the data collected during the above period concerned harvest operations which are considered to be crucial to the transit of information (in terms of both data implementation and transmission) from the olive growers and the oil mill.

The surfaces obtained by the mathematical model (dynamic lots) are in Figure 4.

Figure 4. Graphic representation of dynamic lot

The different areas of land (see figure 4) are function, primarily, from the heterogeneous nature of the olive tree and from the land slope.

It's possible, therefore, by the mathematical model, to determine the origin of olives harvested and to trace the entire route, thus ensuring greater food security.

In conclusion, as already mentioned, the study carried out has been intended to detect any mismatches, i.e. errors of manipulation or of registration, by the dynamic lot, likely to compromise the identification of the product traced in a view to suppressing any sources of risk in compliance with the requirements of EC Reg. 178/2002.

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